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WITH AN ASTRONOMER ON AN ECLIPSE EXPEDITION[1]

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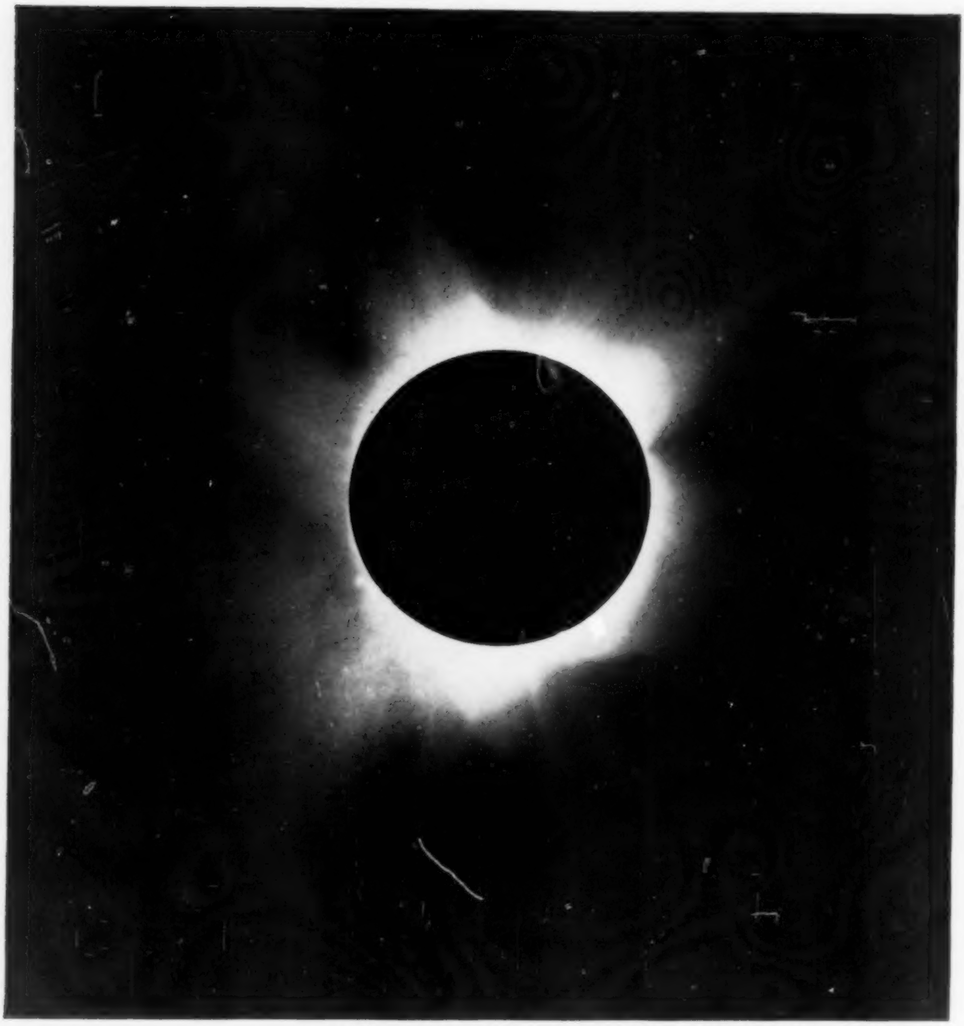
FROM the time of the earliest recorded eclipse, that of the year 2137 B.C. described in the ancient Chinese classic "Shu Ching," the coming of a total eclipse has always been regarded with fascinating interest. To-day amongst all the wonders of all the wonderful sciences there is no science which deals with such a gorgeous spectacle as that vouchsafed by nature to the oldest and most abstract of the sciences, astronomy, at the moment when the earth is gradually shrouded in darkness and when around the smiling orb of day there appears the matchless crown of glory, the corona. Nor can any science duplicate the wonderful precision shown by the work of the astronomer in his ability to predict, hundreds of years in advance, the exact hour and minute at which an eclipse will take place and the locality on the earth's surface where such an eclipse will be visible.

The modern scientific method of investigation, that of experimentation, came into vogue about the time of the 1842 total eclipse which was greeted at Milan with shouts of "long live the astronomers," who had provided so beautiful a phenomenon to please and interest the populace. The unexpected beauty of color and form of the prominences and corona, coupled with the discovery of Baily beads, and in the year following the discovery of the periodicity of sun-spots, caused an unprecedented increase in interest in the physical constitution of the sun. If one of our present-day enthusiastic eclipse astronomers had been alive at that time and with long life and unimpaired vigor had been permitted to take part in each eclipse expedition from that day to this, and if he had had to take his average run of luck with the weather, he would have been permitted one precious hour of sixty golden minutes to secure all his observational material. Among all the wonders of modern science, it is safe to state that the eclipse astronomer eclipses the performances of any other scientist in the wealth of information gleaned per hour spent in securing the observations.

Photography was employed with success at the eclipse of 1860 and by its means it was proved that the prominences belonged to the sun. The first triumph of the spectroscope at eclipse time was the discovery of helium in 1868, though it was not isolated as an inert gas until 1895. Coronium was discovered in 1869, and even to-day we do not know its physical constitution. Before the eclipse of 1870, Young foretold a sudden change in appearance of the spectrum of the sun

[1] Based on the Penrose Memorial Lecture delivered in Philadelphia on April 22 at the annual meeting of the American Philosophical Society.



Photographed by I. C. Gardner, of the National Bureau of Standards
THE CORONA OF JUNE 8, 1937.

at the time of the beginning of totality, from dark lines on a bright background to the sudden flashing out of bright lines on a dark background. His were the first eyes to see the spectrum of the chromosphere called by him the "flash spectrum," which was first photographed but very imperfectly at the eclipse of 1893. With better and better photographic plates, each eclipse, especially since 1900, has been assiduously observed, distances away from home and difficulty of access being no insurmountable obstacles to the eclipse observer.

The 1937 eclipse will go down in history memorable for three different reasons: first, for the longest duration of totality in more than twelve hundred years (since the year 699); second, for the fact that the eclipse began on June 9 and ended on June 8, the day before it started; and third, in spite of isolation and long distances interested persons could listen in on frequent broadcasts

that told of the life on the island and of the preparations over a coast-to-coast network. Two of the broadcasts were specially dramatic, one of fifteen minutes' duration with the phenomenon of the total eclipse at the middle of it, the other a few hours later when the scientific leader of the expedition from Canton Island held a broadcasted conversation with London half way round the world. In the great metropolis was a friend of many years' standing, Alfred Fowler, a distinguished astronomer who in 1893 had made the first photograph of the flash spectrum which since the year 1900 has been my own chief interest at eclipses.

Since the turn of the century, eclipse expeditions to the tropics have fared rather badly from the weather. The writer was a member of a large expedition that went half way round the world to Sumatra to observe on May 18, 1901, an eclipse in the same series with the June 8, 1937, eclipse. With thirteen in the party, this number was unlucky for nine of the expedition, who saw the eclipse entirely eclipsed by clouds. I was one of the fortunate four who photographed the eclipse.

My own second eclipse in the tropics was on October 21, 1930, on "Tin-Can Island" in mid-Pacific. Eclipse day broke with a steady drizzle. First contact was lost in heavy clouds. There seemed no hope whatever—but a quarter of an hour before totality the clouds cleared away beautifully and did not gather again until half an hour after the important 93 seconds of totality had been clicked off.

Luck had been with me in the tropics, two times out of two. It seemed foolhardy to tempt Providence again by going to a third eclipse in the tropics! But an eclipse astronomer must always be an optimist.

It was near the end of January, 1937, that the National Geographic Society

THE PROGRESS OF THE 1937 ECLIPSE
PHOTOGRAPHS WERE MADE EVERY FIVE MINUTES FROM FIRST CONTACT (BOTTOM). THROUGHOUT THE TWO HOURS THE ONLY CLOUDS THAT INTERFERED ARE SEEN AT THE FIFTH EXPOSURE ABOVE THE TOTAL ECLIPSE (CENTER).

through the chairman of its committee on research first proposed an eclipse expedition. It took about a month to work out the preliminary plans and to permit the announcement that the expe-

THE UNITED STATES NAVY LANDING SUPPLIES AND EQUIPMENT FOR THE ECLIPSE EXPEDITION.

dition was to be under the joint auspices of the National Geographic Society and the United States Navy.

The scientific leader of the expedition was S. A. Mitchell, director of the Leander McCormick Observatory. He was assisted by: Professor F. K. Richtmyer, Cornell University; Dr. P. A. McNally, director, Georgetown University Observatory; Dr. Theodore Dunham, Jr., Mount Wilson Observatory; Dr. Irvine C. Gardner, National Bureau of Standards; John E. Willis, U. S. Naval Observatory; Charles Bittinger, Washington, and C. G. Thompson, New York City. In addition there were: Richard H. Stewart, staff photographer of the National Geographic Society; George Hicks, announcer for the National Broadcasting Company, and Messrs. Brown and Adams, engineers of N.B.C. The party thus consisted of twelve, eight to take care of the scientific program and four to handle the photography and broadcasting. Captain J. F. Hellweg, U.S.N. (retired), superintendent of the U. S. Naval Observatory, was in charge of the Navy's participation in the expedition.

Before the eclipse plans had been formulated the maneuvers of the U. S. Navy had been planned to take place just about the same time that the expedition expected to depart from Honolulu. It was with regret that the Navy was unable to put at the disposal of the expedition a vessel any larger than U. S. S. *Avocet*, a mine sweeper of about one thousand tons, converted to an aviation tender by having sleeping accommodations for twelve. The *Avocet* was the same size as the *Tanager*, which had been our mother ship at the 1930 eclipse. Then the *Tanager* and the *Ontario* carried the expedition and its equipment 300 miles from Pago Pago to Niuafoou in the Tonga group. This year, with more equipment and greater scientific personnel, the *Avocet* carried the party six times as far as in the earlier eclipse. The twelve of us slept in one room athwartships in size about 15 by 25 feet. Going south from Honolulu we had a following breeze with the result that the heat from the engine room was wafted just abaft to our commodious quarters, where we had about as much privacy as the proverbial goldfish.

After a well-planned broadcast on May 6 lasting from 10:30 to 11:00 A.M. (Honolulu time), in which Governor Poindexter, Admiral Murfin, scientists and Navy officers participated, we were given a grand send-off to the strains of "Aloha" by the Royal Hawaiian band. It was quite thrilling but none the less a little depressing, for we could not know what luck had in store for us.

At daylight on the morning of May 13,

Enderbury Island of the Phoenix group was dead ahead and we could see the "landing place" described in the pilot book. At 8 : 30 A.M. we were in close to the island and cruised along the west side as far as the landing but found no anchorage with the water close inshore 100 fathoms deep. The duration of totality was 30 seconds longer on Enderbury than on Canton Island on account of a position closer to the center of the moon's shadow path, but in spite of the shorter duration it was much easier to have a successful expedition on Canton Island. The island consists of a narrow strip of coral 400 yards wide surrounding a lagoon, the average height of the island being 10 feet above sea level, the highest point 10 feet greater. There was excellent anchorage at the mouth of the lagoon on the west side of the island, where the prevailing trade winds and the tidal currents would keep the vessel off shore in case the anchor was dragged with no steam in the boilers. On the afternoon of May 13 the first party went ashore. I myself have always believed thirteen a lucky number and so I was quite willing to be a member of a party of 13, to land on the 13th and have 26 days or twice thirteen before the day of the eclipse.

Ashore were found some old timbers from a wreck, which were dragged to the edge of the lagoon and a wharf constructed. With the efficient help of the Navy it was a comparatively simple matter to load the 150 cases of instruments, the 10,000 board feet of lumber and 60 bags of cement into the Navy launches in the quiet waters at the anchorage and put everything ashore on the wharf in

BROADCASTING BIRD VOICES FROM CANTON ISLAND

A BIRD IS IN THE HANDS OF THE SAILOR TO THE RIGHT, AND TO HIS LEFT MAY BE SEEN A CORNER OF THE "MIKE." THE BIRDS HELD BY THEIR WINGS ARE A MAN-O-WAR, AND A BLUE-FACED BOOBY IN THE FOREGROUND.

I. C. GARDNER (RIGHT) AND R. H. STEWART WITH THE CAMERA CONSTRUCTED UNDER THE DIRECTION OF THE FORMER.

the still quieter waters of the lagoon. Twenty tents and a mess tent constituted our homes ashore. Canton Island is at 173° west longitude. Its three degrees of south latitude makes June 21 the shortest day in the year, the sun rising five minutes after six, so that the difference between the longest and shortest days of the year is a mere twenty minutes.

The only trees near us were a half dozen sad-looking coconut palms that would afford no shelter from the blistering tropical sun. In fact, the disintegrated coral reflected the sun's rays so thoroughly that we got a double dose of the sun's heat. However, the temperatures were not high, for the ever-constant trade winds blew over the waters of the lagoon so that the temperatures ranged from 80° F. at night to 85° at midday. The siesta that usually accompanies life in the tropics was not to be ours, for the simple reason that the time ashore was all too short as it was to erect and adjust the instruments. Except for the heat (and that was part of the game) the site was ideal for an eclipse expedition. The instruments were set out along a meridian comparatively close to the edge of the lagoon. Immediately behind were two rows of tents and behind these the mess tent and galley. On the expedition which kept the *Avocet* away from Honolulu for 42 days or six weeks, we ate what was carried by the ship, though on the island we did have fresh fish on two separate occasions.

Afloat and ashore we kept Honolulu time ($10\frac{1}{2}$ hours W. of Greenwich). During the weeks of preparation on Canton Island we had the advantage of one hour of daylight saving time. As the sun rose at approximately six o'clock local time, it did not rise until seven o'clock by our clocks, at which hour everybody was

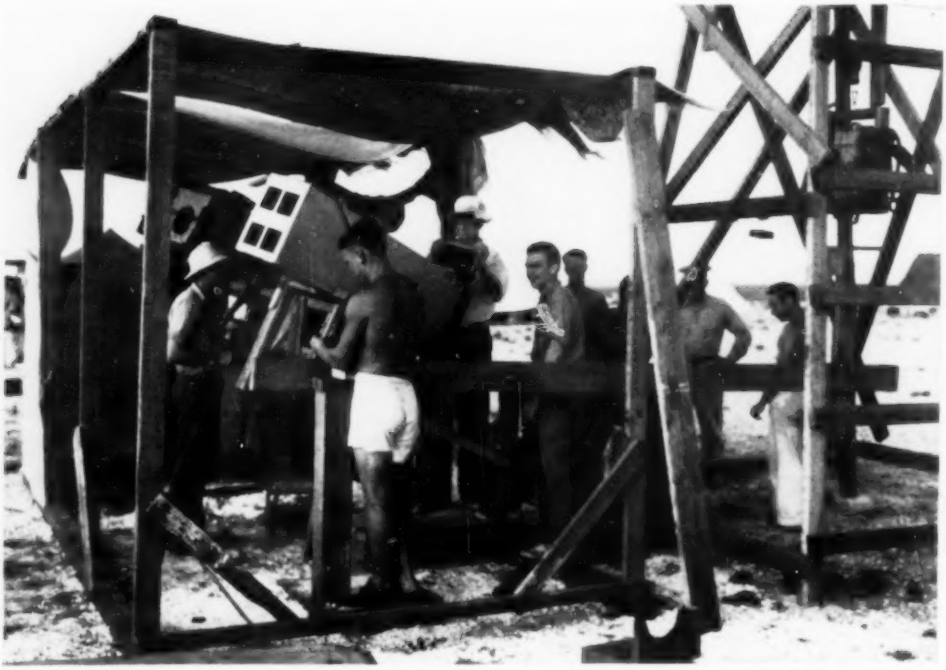
ready to get up without grumbling and go to work. We worked until noon and had dinner and again until late in the afternoon. Before supper at six o'clock we had time to have a swim in the lagoon, the only bath tub for the party ashore. Outside at the anchorage, the waters teemed with fish of all sizes. The waters also teemed with sharks of all sizes. Frequently while the sailors were hauling in a good-sized fish a shark would bite it in two before it could be taken aboard. We have heard it said that sharks are not man-eaters—but possibly that remark refers to sharks in the Atlantic Ocean. Although as scientists we are accustomed to make experiments, yet strangely enough none of us were anxious to make the shark experiment in the Pacific Ocean. Even in the lagoon just off our wharf we caught a 5-foot shark on a line. When it was cut open it had five baby sharks, one of which swam off when put in the water. Perhaps we should not have gone in swimming in the lagoon with so great danger from sharks so close at hand—but we took the precaution of not going far from shore and also of keeping a wary eye always for a disturbing fin.

Ashore there was not much of interest aside from our work except to watch the sea birds, the hermit crabs and the rats. The hermit crabs follow the custom of the tropics and take a siesta in the middle of the day in the shade of a rotten timber or a sheltering rock. At dark they are ready to make off in search of food, for they are the scavengers. At night when lying in our cots we could hear them dragging their borrowed homes, their shells, over the coral of our tent floor. After we had learned to put our shoes and garments out of reach, we could sleep without worrying about the loss of articles of personal use. One morning I found that my one and only tube of tooth paste had vanished. I am a methodical person and carefully screw the cap on the paste after each use. A short search in the tent revealed the tooth paste but rather battered as to outside appearance. Believe it or not, the screw cap was gone! I found it two days later two feet away from the rest of the tube.

With much of work and pleasant companions, time passed very quickly. After dark we had no illumination other than barn lanterns, so we had plenty of time to watch the heavens. Our tents had been pitched so that the opening at noon would be directed away from the sun and hence faced the south. We had a chance to feast our eyes on what is perhaps the most beautiful part of the sky, namely, the Southern Milky Way in the vicinity of the Southern Cross.

On May 26, H. M. S. *Wellington* arrived at Canton Island bringing the New Zealand party of eight, two of whom had worked alongside me at the 1930 eclipse on Niuafoou. I was very glad to renew old friendships. We laid out a meridian for them and helped them orient their instruments; we had them to Sunday dinner when we had roast chicken and in turn they had us to a smoker or two. The American sailors entertained the British tars ashore to a field day, at which there were pie-eating contests, three-legged races, boxing bouts, etc. In return the American sailors were entertained on board the *Wellington* to a social evening.

On eclipse day we were awakened by a loud-lunged sailor at 4:40, though some of the expedition had been up all night in last-minute preparations. It had been clear in the early evening but had clouded up at three in the morning and it was hopelessly cloudy when we emerged from our tents. There was a broadcast at 5:30 A.M., at which time we gave impressions of the weather at earlier eclipses and voiced our fond hopes for clear skies. Although it was densely cloudy, we could still be optimists and could hope for the best. Breakfast was at six o'clock under the light of lanterns,



F. K. RICHTMYER TRAINING HIS ASSISTANTS.

with the clouds broken some but the skies quite bad towards the east. The sun rose about seven in a bank of clouds but with general conditions much improved. A quarter of an hour later the whole sky was clear except for floating clouds here and there. We were in great good luck, for the only cloud over the sun from first contact which came at 7:35 through to fourth contact was a thin one that passed over the sun about five minutes after the precious photographs had all been taken. Throughout the eclipse the sky seemed brilliant. Evidently the combination of thirteens had been the lucky numbers.

The corona was perhaps the most beautiful I had ever seen in all my ten total eclipses. Although a year before the expected time of sun-spot maximum, the corona was of spot maximum type, extending quite uniformly in circular outline to one solar diameter around the dark moon. Beyond there were many streamers and long spikes going off at many angles. These could be traced to about two diameters from the sun's edge, while on one of the photographs taken by Richtmyer the longest streamer was six diameters or five million miles in length. The beauty of the 1937 corona came mainly from the many long spikes. There were some prominences, principally those at seven and eleven o'clock, as they say in the Navy, but none of them were conspicuously large.

The general shape of the corona can be predicted in advance of the eclipse, depending on the sun-spot cycle. Recently it has been found that the "minimum type" of corona, with long equatorial streamers and strong polar brushes, does not occur at the time of minimum of spots but one and one fourth years earlier. Likewise, the corona closest in shape to a circle takes place one and one

fourth years before spot maximum. The eclipse of 1932 took place 1.2 years before minimum of spots, and its shape was the pronounced elongated type. The succeeding total eclipse of 1934 was only 0.2 years after spot minimum, and yet the corona had lost its minimum-type features and much more closely resembled the circular or "maximum-type" corona.

Many attempts have been made to detect motions of coronal materials but without pronounced success. A comparison of Swarthmore and Lick photographs of the 1918 eclipse seemed to indicate motions of the order of 10 miles per second, but at the 1926 eclipse a comparison of coronal photographs made in East Africa and Sumatra revealed that any motions in the corona were no more than one mile per second, or no greater than the inherent errors of measurement. The few spectroscopic measures that have been made seem to indicate motions away from the sun at speeds of 15 miles per second, though the evidence is not very convincing and needs to be verified.

Valuable information regarding details of coronal radiation were secured on Niuafoou in 1930 from large-scale spectra taken with a concave grating without slit when the coronal lines are rings of light and not the customary straight lines one expects in spectra. The spectrograms were compared with the direct photographs of exquisite detail in the corona and also with spectroheliograms taken on four successive days thousands of miles away at Mt. Wilson or Kodaikanal Observatories. All the photographs tell of an intimate connection between coronal streamers and prominences but also that the streamers, on which the shape of the corona more or less depends, are always located near prominences but are not necessarily exactly connected with those prominences which at the time of the eclipses are of the greatest height. The eclipse spectra showed that the details of the coronal structure in the green "coronium" line at 5,303 Å differed greatly from the details found in the red line at 6,374 Å.

In the report of the Commission on Eclipses presented to the International Astronomical Union at its last meeting in 1935, it seemed that we might be on the verge of a fairly complete understanding of the method whereby the light of the corona is diffused and scattered. Grotrian had found that the distribution of energy in the spectrum of the corona is identical with that in the solar spectrum, the dark lines in the spectrum of the outer corona giving fair indication that the light of the corona is scattered sunlight. At the 1932 eclipse, Dufay and Grouiller had shown that the amount of polarization in the corona is entirely independent of wave-length and is a maximum of 26 per cent. at an angular distance $10'$ from the sun's limb.

Other observers, however, have come to quite different conclusions. From the two eclipses of 1932 and 1934 Cohn finds that the polarization in the corona is quite different for short and long wave-lengths. In fact, the polarization in the integrated light, in the blue and in the red increases steadily from the sun's limb toward the outer corona, whereas it reaches maxima both in the violet and in the green and then decreases again. At $4'.5$ from the sun's limb the polarization is actually independent of wave-length, but at smaller distances in the inner corona the polarization is higher for short wave-lengths than for long wave-lengths. At the 1936 eclipse, Zakharin confirms the conclusions of Cohn that the degree of polarization is different for different regions of the spectrum.

Likewise our knowledge regarding the law of distribution of light within the corona is in a very unsatisfactory state. There are many laws of intensity found by various observers, such as the 2nd, 3rd, 6th, 7th, 8th and such powers as 2.3 or 2.4 of the distance measured either

S. A. MITCHELL PUTTING INTO LINE HIS THREE CONCAVE GRATING SPECTROGRAPHS.

from the center or from the edge of the sun. At the 1936 eclipse, the Polish expedition found that the intensity of the coronal radiation measured from the sun's limb outward diminished more rapidly in red light than in yellow, while the Italian photographs at the same eclipse showed that the intensity in the blue also diminished more rapidly than in the yellow.

In view of much conflicting evidence it is very important that measures both of intensity and of polarization be repeated in different wave-lengths by many different observers. For polarization measures there has come a great simplicity of technique through the application of "polaroid" to eclipse work, which had been done both at the 1936 and 1937 eclipses. At the 1937 eclipse on Canton Island, F. K. Richtmyer secured successful photographs which are now in the process of measurement and reduction.

Accurate values of the total light of the corona have been derived by Richtmyer and by Stebbins in Peru, each using a photoelectric cell. The two results are in good agreement, namely, 53 and 47 per cent., respectively, of the total light of the full moon. From the ten most reliable measures previous to 1937, the average showed the total coronal light 47 per cent. of the full moon.

Measures by illumination meters of the intensity of light of the corona plus illuminated sky have given much conflicting information for the reason that it has been impossible to adequately allow for the effects of sky illumination. In spite of the conflicting evidence, however, some astronomers have reached too hasty conclusions in their attempts to correlate intensity of coronal radiation with sunspot activity. It does indeed seem probable that the inner corona at spot maximum must be brighter than at spot minimum. Moreover, as the inner corona

contributes the greatest part of the energy of the total coronal radiation, we would logically expect that the total energy at maximum of spots would be greater than at minimum. Unfortunately, eclipses come but seldom and there are far too few observations from which to derive any satisfactory correlations.

In spite of many inconsistencies in the results, observers throughout the past fifty years have been in substantial agreement that the total light of the corona is roughly one half that of the full moon, or one millionth that of noonday sun.

In the year 1882 a bright comet was observed near the eclipsed sun, but was never seen before nor since. The corona appeared so bright that attempts were made to photograph the corona without waiting for an eclipse. Attempts followed attempts with every conceivable variety of attack—and failure to achieve results followed failure for fifty years. In fact, it was not until 1930 that Lyot, of the Meudon Observatory, achieved a brilliant success where others had repeated failures. His great triumph resulted from the ingenious arrangement of his telescope to reduce to a minimum the amount of scattered light inside the instrument. A mountain observatory on the Pic du Midi (9,100 feet) and at times very transparent skies permitted photographs of the brighter parts of the corona in full daylight, but he also derived accurate wave-lengths of eleven emission lines of "coronium," three of which at great wave-lengths have not been photographed at eclipses.

In addition to the eleven lines measured, there are twelve other lines in the spectrum of the corona that have been observed by others at many eclipses. Consequently, there is a total of 23 known emission lines. In addition, at the 1936 eclipse two Japanese expeditions publish a total of 11 other lines in the region of between 5,000 and 7,000 Å where Lyot's spectra were photographed under the best conditions. These lines are faint and need to be verified by future observations.

It may be said that the corona exhibits three separate spectra: first, the emission spectrum in the inner corona extending to 5′ or 200,000 km from the sun's edge; second, the continuous spectrum (without lines) in the middle corona; and third, the Fraunhofer lines showing feebly in the outer corona. In the continuous spectrum it has been found that there is a band of absorption at wavelength about 6300 which has a greater intensity in the corona than in the photosphere. At the 1936 eclipse the same band was photographed in the spectrum of the light of the sky during totality. The same band appears in the spectrum of twilight, in the spectrum of the night sky and also in the spectrum of the aurora borealis. In accordance with the theory of Störmer that aurorae are caused by corpuscular radiation from the sun, then it must happen that at the time of intense solar activity there would be a strong aurora on the side of the earth turned towards the sun. The band seen in the 1936 spectra needs to be confirmed at future eclipses but it does look probable that it is actually the auroral band which one would expect to be strong near the time of sun-spot maximum.

By comparing wave-lengths east and west, Lyot finds that the inner corona rotates at a speed about equal to that of the photosphere.

In comparing the green and red coronal rings obtained in 1930 on spectra taken with a concave grating and without slit, it was surprising to find how little the lines resembled each other in their structural details or how little either resembled the H and K lines in the chromosphere. It is evident that these two lines can not take their origin in the same atom, or at least, not in the same atom in the same state of ionization.

In spite of many attempts, no further progress has been made in deciphering the source of coronium.

In elucidating the enigmas of the corona much substantial progress has been made, but yet there are many unsolved problems. According to Rosseland, "the corona has stimulated speculation to the breaking point, it being even suggested that there we witness our recognized physical laws set at naught by nature itself." It is evident that the cause of the coronal radiation can not be found in the emission spectrum of coronium, which contributes only a very small fraction to the total energy of coronal light. We must therefore seek the explanation of the mysterious corona in the spectrum of the middle and outer corona.

As the result of many different theories, it is now generally recognized that the electron must play an important rôle in explaining the radiation of the corona. If the continuous spectra is caused by free electrons, then the average thermal velocity of the electron would cause a Doppler effect of the order of ten angstroms which would effectively wipe out all Fraunhofer lines with the exception of the broad wings of the H and K lines. Electron scattering will give an adequate explanation of the absence of dark lines in the inner corona and also is in conformity with the fact that there is little difference in energy distribution between the radiation of the corona and that of scattered sunlight.

In future eclipses there is a great need of carefully designed spectrographs of great speed and large dispersion. At the 1937 eclipse, Dunham had the most powerful spectrograph ever used at an eclipse, for he had virtually a duplicate of the one used with the 100-inch Mt. Wilson reflector. With smaller dispersions we need to compare the intensity distribution of the coronal light with that of the photosphere, and we need more and better spectra that will give the dark lines in the outer coronal spectrum that should be taken under clear skies devoid of water vapor in order that the photographs may verify that the Fraunhofer lines are coronal in origin and do not come from sunlight scattered in the earth's atmosphere.

Lyot has contributed much valuable information to the emission spectrum of coronium, but the outstanding problems connected with the corona will be solved only by observations made at total eclipses. The chief difficulty is that on the average only one minute per year is given to any astronomer to secure his important observations. The next total eclipse to be observed will be on October 1, 1940, visible in Brazil and South Africa.

In recent years the chief contributions from observations made during total eclipses of the sun have had no connection with the corona but have been in two widely separated fields of investigation. In 1919, at the eclipse which was the forerunner in the Saros cycle of the eclipse of June 8, 1937, the whole world was electrified by the confirmation of the Einstein prediction that rays from stars are bent when under the influence of the strong gravitational pull of the sun. Although the splendid observations at the 1922 eclipse seemed to give a complete verification of the Einstein value, it was found by Freundlich from observations at the 1929 eclipse that the deflection at the sun's limb was considerably greater than 1."75 required by theory and amounted to 2."24. The chief trouble with eclipse plates is that the same stars which furnish the relativity displacements must also give the scale of the photographs. The stars at the 1929 eclipse were badly distributed around the sun, as is seen by the fact that out of a total of 18 stars used to measure the relativity effect there were 17 stars located on one side of the sun and only one star on the other side, with the result that

THE MOST POWERFUL SPECTROGRAPH EVER USED AT AN ECLIPSE
T. DUNHAM, JR. AND C. G. THOMPSON ADJUSTING THE MOUNT WILSON INSTRUMENT.

scale value was poorly determined. A discussion by Trumpler of all observations at the eclipses of 1919, 1922 and 1929 gives the relativity deflection reduced to the sun's edge as $1''.79 \pm ''.06$.

In view of the discordant results from the 1929 eclipse, it is evidently necessary to repeat the observations, devoting special care to a more accurate determination of the scale value of the photographs. Unfortunately, this obvious recommendation can with difficulty be put into effect for the reason that the star fields at total eclipses in the next twenty years do not contain a sufficient number of bright stars. In spite of these drawbacks, the British astronomers are planning to again test the Einstein deflection as a part of a very extensive program of observations for the 1940 eclipse.

The sun is the nearest of the fixed stars, and it is the only star which permits a detailed study of conditions in the outlying atmosphere. As these conditions have gradually become understood in the sun they have furnished the method of interpreting many outstanding stellar problems. Perhaps the greatest contribution in recent years from eclipse observations has been the rather perfect knowledge of heights to which the gases of the chromosphere extend above the surface of the sun. Photographs of the flash spectrum taken without a slit give a spectrum of curved arcs from which heights are immediately derived. From these heights furnished to

Saha fifteen years ago he was able to compute the conditions of temperature and reduced pressures that causes an atom to lose an external electron and become ionized. His theory of ionization coupled with increased knowledge of the structure of the atom has made the past fifteen years the most prolific and most exciting years in the whole history of astronomy.

All the prominent lines in the spectrum of the sun have been assigned to multiplet groups with known excitation potentials measured in electron-volts; the arbitrary intensity scale of Rowland has been submitted to calibration tests which have revealed that the intensities depend on the number of atoms engaged in the formation of the spectral lines. From the weakest iron lines perceptible in the solar spectrum to the strongest the number of atoms involved increases about one million times.

A person with no knowledge of the theory underlying multiplet groups would not advance very far in the practical operation of correlating heights from eclipse spectra with intensities before the

MITCHELL AND A BABY MAN-O-WAR BIRD.

THE MAN-O-WAR OR FRIGATE BIRD EXHIBITING HIS BRILLIANT TURKEY-RED POUCH.

fact would be forced upon his attention that the lines of greatest intensities generally reach the greatest heights, and moreover for any element considered, the intensities and heights are greatest for lines of lowest excitation potential.

Fascinating work on sun-spots was started by Evershed and carried through to completion by St. John, using the 150-foot tower telescope of Mt. Wilson. With the slit of the spectrograph placed across the image of a spot it was found that the wave-lengths in the penumbra of the spots were different from the values at the center of the sun. These "Evershed displacements," as they are called, affect practically all lines, but the amount depends on the intensities of the lines. The heights derived from eclipse spectra furnish the explanation. The layers closest to the sun's surface have a motion of translation out of the spot at the rate of 2 km per sec. At greater and greater heights this motion becomes less and less in amount. At a certain level, the outward motion of vapors ceases and at still greater heights

the motion of translation is in the opposite direction into the spot. At the maximum heights reached by the H and K lines of Ca^{+}, the speed of motion into the spot is 3.8 km per sec.

The Evershed effect shows that there is a circulation of gaseous material in the neighborhood of sun-spots or, in other words, that each sun-spot is a great vortex.

One consequence of the Einstein theory of relativity is that wave-lengths in the sun must be greater than in the laboratory, the amount of shift to the red depending on the wave-length. The best element for determining the red shift in the sun is iron. From the discussion of abundant material coupled with a knowledge of heights from eclipse spectra it is evident that the relativity shift is most certainly present, but in addition there are systematic differences between the effects shown by the strong and the weak iron lines, the strong lines being those that extend to great heights in the sun. The systematic differences are most readily explained as a Doppler shift caused by a circulation of vapors in the sun's atmosphere. On account of the higher temperatures and higher pressures near the photosphere, the solar activity causes the *Fe* atoms to ascend through the medium of thousands of weak lines of high excitation potential. In the upper reaches of the chromosphere under reduced pressures some of the atoms lose an external electron and become ionized. Later the atoms descend from their maximum heights and in their descent some of the atoms gain an external electron and again become neutral. According to this interpretation, in a direct photograph of the sun showing a mottled surface, the atoms ascending exhibit themselves over the small bright granules and the descending ones over the larger dark interspaces, the observed effect being an integrated one.

In the celestial laboratory of the sun the astronomer has available for his researches very high temperatures and very minute pressures far transcending the conditions available to the physicist in terrestrial laboratories. As the result of a knowledge of the structure of the atom, Henry Norris Russell and others have assigned practically all the strong lines in the solar spectrum to multiplet groups and have ascertained the energy, measured in electron-volts, necessary to produce the spectral lines. From a knowledge of the multiplet intensity formulae it has been possible to learn the relative numbers of atoms involved in the transfer from one energy level to another in the production of absorption or emission in the sun's atmosphere.

The heights determined from eclipse spectra to which the solar gases extend in the chromosphere have permitted many important correlations. These correlations are shown by the dozen lines of a multiplet involving strong *Fe* lines,[2] where 100 times as many atoms are active in producing the strongest line in the multiplet at wave-lengths 3,820 Å as go to form the weakest line at 3,940 Å. Even within a single multiplet, the heights found directly from the flash spectrum or indirectly from the Evershed effect in sun-spots, are not constant but are greatest in size for the strongest lines and therefore those which extend to the greatest heights and involve the greatest number of atoms.

Again, a knowledge of the heights from the flash spectrum to which the various lines in multiplets are observed combined with information from the number of atoms involved gives important knowledge regarding the density distribution of various elements in the lower chromosphere. The results seem to indicate that turbulence and not radiation pressure is responsible for keeping the different elements so well mixed.

[2] "Eclipses of the Sun," 4th Edition, page 348.

From the flash spectrum there has been determined the relative abundance of various elements and the results from the chromosphere have been compared with the abundances found in the sun's reversing layer, in stellar atmospheres, in the earth's crust and in stony meteorites. It is shown that within errors of observation the composition of all samples are alike, with the exception that hydrogen is conspicuously deficient in the earth's crust and in meteorites and is probably much more abundant in the chromosphere than in the reversing layer.

The eclipse of 1936 was observed throughout Siberia and Japan with much interference from clouds while the 1937 eclipse had clear skies everywhere. In 1936 the British expedition in Japan under the direction of Stratton obtained excellent results in spite of many clouds, while in Siberia the Harvard-Massachusetts Institute of Technology expedition under the guidance of Menzel secured carefully standardized and calibrated spectra with large dispersion in the spectral region 3,200–10,000 Ångstroms. In Siberia, Williams found 12 new lines in the chromosphere in the infra-red with wave-lengths between 9,000 and 10,049 Å. He also photographed eight lines of the

A SCENE ON CANTON ISLAND
SEA-BIRDS RESTING IN THE SAD-LOOKING COCONUT TREES. ON THE PALM TO THE LEFT WE FOUND A NOTICE STATING THAT A YEAR PREVIOUSLY THE ISLAND HAD BEEN TAKEN OVER IN THE NAME OF HIS MAJESTY, KING EDWARD VIII.

HERMIT CRABS ON CANTON ISLAND
IN THEIR BORROWED SHELLS EATING COCONUT.

Paschen series of hydrogen. At the 1937 eclipse on Canton Island, Dunham secured spectra of the chromosphere and corona with large dispersion and jumping-film. Mitchell obtained spectra with three concave gratings without slit. In the infra-red with the Allegheny grating he photographed the strong calcium triplet and also 25 lines of the Paschen series of hydrogen. Also he photographed the strong coronium line at 7,892 Å., this line having been discovered in 1925 by Curtis and Burns using the same grating.

At the 1936 eclipse from spectra taken outside of totality, Royds, of the British expedition, found that the red shift at the sun's limb is the same in amount inside and outside an eclipse, thus ruling out the possibility that scattering in the earth's atmosphere is the explanation why strong and weak spectral lines show different relativity shifts. In the same expedition, Thackeray finds that the in-

tensities of lines in the Balmer series of hydrogen are in close agreement with the theory of Menzel that the hydrogen lines owe their intensities to some form of excitation in addition to straight electron capture. From the 1937 eclipse Mitchell finds a similar agreement for the intensities of the Paschen series of hydrogen.

Menzel and others at Harvard have published valuable results from the 1932 spectra. Information is given about multiplet intensities and density gradients, self-reversal of hydrogen lines and the general theory of curves of growth and self-reversal of emission lines. Mitchell has nearly ready for publication a discussion of the October 21, 1930, eclipse which will give a redetermination of heights and the density distribution of gases in the chromosphere.

On account of the great activity in recent years of eclipse observers, particularly the American and British, most of the problems have been cleared up that might be attempted by interested amateurs with moderate equipment. There are many mysteries still connected with the corona, with the chromosphere and with the relativity displacements. For instance, from spectra taken at the 1936 eclipse it was found by Thackeray that the emission lines of neutral metals show an unexplained displacement to the violet relative to limb absorption. The emission lines in the chromosphere, if secured with excellent definition, can give valuable information about line profiles which in turn will give further information about the structure of the atom and the mechanism whereby lines in spectra are produced.

In planning for future eclipses, the British have a great advantage over us in the United States, for the reason that our British cousins see each other very frequently at the monthly meetings of the Royal Astronomical Society. With us in the United States, eclipse expeditions become possible only when some interested person is able to raise the rather large amount of money necessary, while in Great Britain the expeditions are handled more efficiently by the Joint Permanent Eclipse Committee organized under the auspices of the Royal Society and Royal Astronomical Society.

GEOLOGY OF SOIL DRIFTING ON THE GREAT PLAINS[1]

By Dr. M. M. LEIGHTON
CHIEF, ILLINOIS STATE GEOLOGICAL SURVEY

I

No subject is more important to mankind than that of husbanding natural resources. Among natural resources, none is more important than soils. Directly or indirectly they provide us with food; their well-being determines our pleasure and comfort; their fixity—or lack of it—has profound effects on our health. Without soil in virtually stable condition civilization can not exist.

All this is everyday knowledge; to some degree it has been apparent for many centuries. But to know is one thing; to act is another. As Sears[2] has shown, human settlement and land use have led, without significant exception, to wholesale wastage of soils. This waste has gone so far that the need for conservation is immediate and pressing; it challenges any enlightened people. Even in the most fertile areas of new countries such as ours, the natural productive capacity of the soil has been greatly reduced by prevailing methods of grazing and farming. This reduction has dollars-and-cents importance. It also presents a grave problem which affects our national future.

The drifting of soils by wind is one very serious phase of the matter. In the Great Plains, our once-wild West, drifting already is a menace to soil resources of the great wheatlands. It is almost as threatening in grazing regions. Travelers who cross the Panhandle of Texas, the sage plains of Wyoming, or the grass lands of Montana will see broad stretches whose value is sinking to almost nothing as winds carry soil away.

Spectacular and overwhelming as it is in the Great Plains, soil drifting is important in even the Central Lowlands. During dry seasons, strong winds pile ridges of black, fertile soil along fences and hedgerows of Illinois and Iowa. Flat stretches of plowed land and the plowed brows of slopes suffer alike from air currents, which first carry and then deposit the material in those ridges. Effects may seem trifling during a decade, appearing negligible to the average layman. But their cumulative results will become disastrous unless intelligent practices reduce drifting until it corresponds to the natural rate of soil renewal.

Soil drifting is a wide-spread process, affecting many different types of land. In North America, however, it has specially characterized the region which we term the Great Plains. With that region this symposium deals. My first purpose is to describe geologic conditions of the Plains which favor or control dust storms of the present. I then shall deal with dust storms of the past, in so far as they have lessons for us. Finally, I shall discuss those principles which, from a geological viewpoint, seem specially significant to any sound program of soil conservation.

II

The Great Plains have long been recognized as a wide belt of high country which slopes eastward from the Rockies to the Central Lowlands. Popularly, the name Great Plains is associated with monoton-

[1] Presented in a symposium on the "Scientific Aspects of the Control of Drifting Soils," Denver meeting of the American Association for the Advancement of Science.

[2] P. Sears, "Deserts on the March." Norman, Univ. Oklahoma Press, 1935.

ous landscapes, short grasses and rainfall of less than 20 inches. In general this conception is valid to-day. The Plains contrast sharply with the prairies or "long-grass country" which bound them on the east.

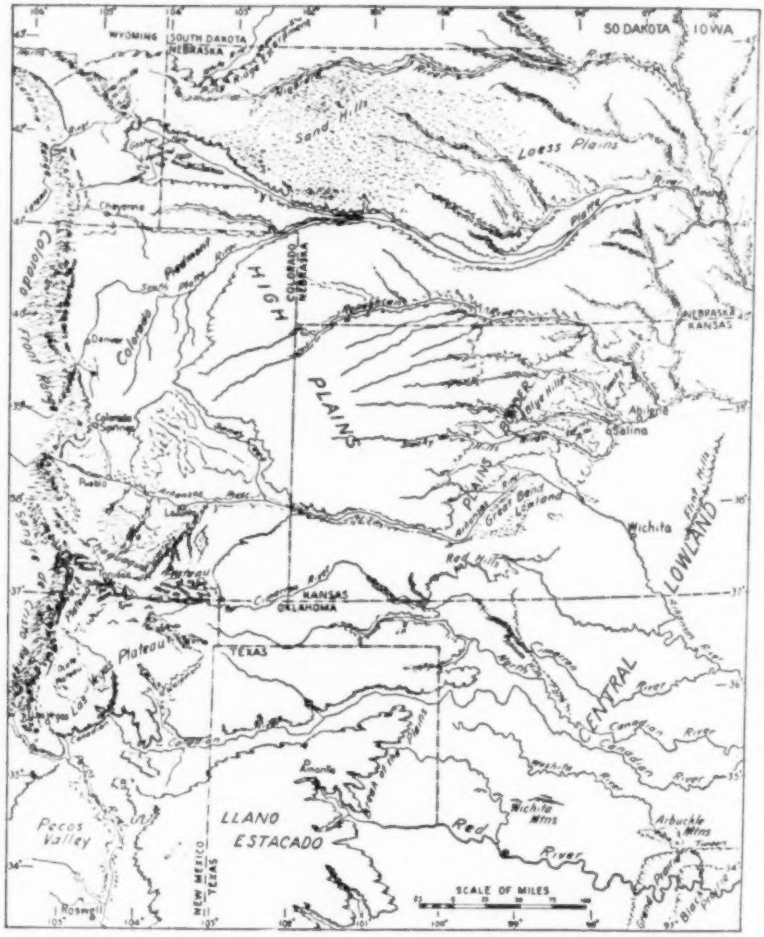
That boundary is indicated in Fig. 1. Throughout much of its length, it is marked by low, eastward-facing escarpments which are continuous in some places, ragged in others and in some places have been transformed into low belts of hills. In Nebraska and South Dakota, however, this boundary is indefinite. From elevations of 1,200 to 1,500 feet along this eastern border, the land rises to heights of 4,000 to 5,000 feet in its western belt, called the High Plains. Streams which originate in the mountains flow eastward and southeastward across the sloping country to the Mississippi and the Gulf of Mexico. Through long ages, these streams and their tributaries have cut valleys, transforming the surface into a landscape which is much more irregular than it generally seems. Only the Llano Estacado and uplands near the Kansas-Colorado boundary remains as extensive, level areas almost untouched by erosion (Fig. 2). The former comprise 20,000 square miles whose surface has been called "as flat as any land surface in nature."[3]

FIG. 1. THE GREAT PLAINS OF THE UNITED STATES

SHOWN BY THE DOTTED AREA (GP). EAST OF THEM LIE THE CENTRAL LOWLANDS (CL) AND THE WESTERN PART OF THE COASTAL PLAIN (CP). THE OZARK–OUACHITA REGION IS NOT INDICATED ON THIS MAP. WEST OF THE PEDOCAL–PEDALFER BOUNDARY (UNBROKEN LINE), LIME ACCUMULATES IN THE SOIL, COMMONLY FORMING CALICHE. (AFTER FENNEMAN AND ATLAS OF AMERICAN AGRICULTURE.)

Except in regions where crystalline rocks reach the surface, both the Great Plains and the Central Lowlands are underlain by sediments. In the Lowlands these stratified rocks may be thin: there are places in South Dakota and Minnesota where they amount to less than 100 feet. Throughout most of the Plains, however, sediments are thousands of feet thick, include many kinds of rock and are grouped into formations of many different ages. These formations outcrop in a narrow belt near the mountains and over great areas in Texas, Oklahoma and Kansas, as well as other Plains states, and these outcrops have provided material for extensive areas of soil. The pre-Tertiary strata (those which are more than 60,000,000 years old) have been bowed downward into a basin-like structure whose rocks dip steeply eastward near the mountains but have gentle westward dips on the east side of the basin. Their variations in hardness, as well as their structure, are expressed in the remarkable linear, subparallel escarpments and ridges of eastern Kansas and in steep, high "hogbacks" near the Rocky Mountain front near Boulder, Denver and Colorado Springs. Most of these

[3] N. M. Fenneman, "Physiography of Western North America." New York, McGraw-Hill, 1931.



Courtesy Mc-Graw Hill Book Co.

FIG 2. CENTRAL PART OF THE GREAT PLAINS

SHOWING THE HIGH PLAINS, LLANO ESTACADO AND THE SAND HILLS. A BROKEN SERIES OF ESCARPMENTS AND HILLS DIVIDE THE PLAINS FROM THE CENTRAL LOWLANDS. DRAWN BY GUY-HAROLD SMITH.

tilted rocks are resistant, but some of the Cretaceous shales which outcrop in Colorado and Wyoming, as well as Triassic "red beds" of the Texas-Oklahoma panhandles, yield readily to erosion by the strong, turbulent winds that are common in those areas.

The older and more indurated strata are popularly called bedrock (BE of Fig. 3). In large areas of western Texas, the panhandle of Oklahoma and western and central Kansas, and in most of Nebraska, the bedrock is covered with relatively young, unconsolidated sediments (TE in Fig. 3). These are the Tertiary deposits, which were washed from the rejuvenated Rocky Mountains and deposited on the Great Plains. Erosion has carved them into hills and valleys and reduced them to remnants along their fringing borders. Throughout considerable areas the surface soils have been made from them. In some places both the soils and some of the parent deposits are readily subject to

wind erosion, especially where they are sandy or silty.

Other very extensive areas are covered with loose, incoherent deposits of wind-blown silt whose origin dates back thousands rather than millions of years. These are the loess deposits of northern and western Kansas, eastern and southern Nebraska; they also extend over large parts of Iowa, Missouri, Illinois, and adjacent territory (L in Fig. 3). As we shall find, the loess consists of old, wind-transported and wind-laid dust deposits which were formed at various times, chiefly during the Glacial Period. The soils of these areas have been made from loess.

In the northwestern part of Nebraska, an area of dune sand, amounting to about 24,000 square miles, is known as the "Sand Hills" (S in Fig. 3). Lugn,[4] of the Nebraska Geological Survey, states:

> The dune sand is the material left behind after the fine silt and clay had been sifted out by wind action and carried eastward and southeastward to become the yellow and yellow-gray loess, which was spread over a fan-shaped area of tens of thousands of square miles south and east of Nebraska and areas farther eastward.

There are other, though smaller, sand areas in Colorado, Kansas, Oklahoma and Texas. Some or all of them may also have contributed material for loess deposits bordering these tracts.

In eastern North Dakota and South Dakota, as well as most of Minnesota and Wisconsin, north-central Iowa, northeastern Illinois and northern Indiana, most of the soils have been made from pebbly and stony glacial drift. In certain places, as in the Red River Valley of the North, the drift has been reworked into lake silts, laid down in glacial Lake Agassiz and neighboring bodies of water. Elsewhere it lies much as melting glaciers left it. The boundary of the drift area (GL) shown in Fig. 3 does not mark the greatest extent of glaciation in the Mississippi Valley, but it essentially limits the area of drift that is free from loess. The oldest drift sheets, which extend into the southern part of Illinois, northern Missouri, northeastern Kansas, and eastern Nebraska are buried beneath loess deposits.

The fringe of deposits along the Gulf of Mexico, shown as CO in Fig. 3 are of marine origin. Alluvial deposits (AL) are fairly wide-spread along the major valleys, but they are mapped here only along the lower Mississippi.

III

The chief sources of recent dust storms are areas within the High Plains and in

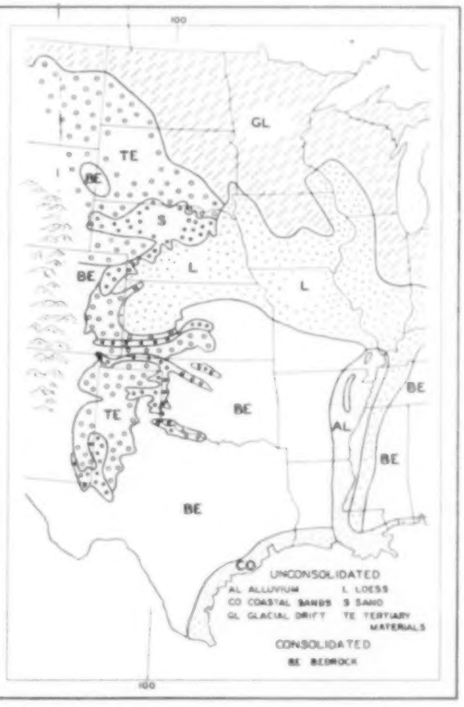


FIG. 3. PARENT SOIL MATERIALS IN THE GREAT PLAINS AND PART OF THE CENTRAL LOWLANDS. AREAS OF "BEDROCK" (BE) CONTAIN FORMATIONS OF MANY DIFFERENT AGES, KINDS AND DEGREES OF HARDNESS. OTHER SOIL-FORMING MATERIALS ARE RELATIVELY UNCONSOLIDATED AND VARIED IN ORIGIN AND CHARACTER.

[4] A. L. Lugn, Nebraska Geol. Survey, *Bul.* 10: 161–162, 1935.

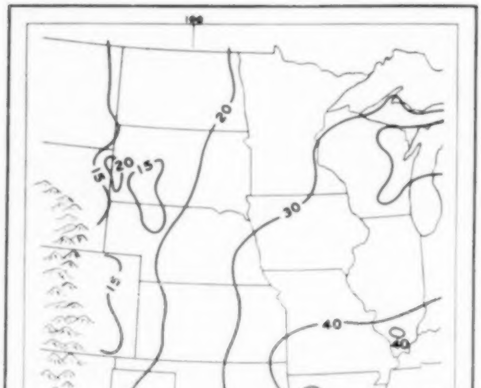


FIG. 4. AVERAGE ANNUAL PRECIPITATION

OF THE GREAT PLAINS AND PART OF THE CENTRAL LOWLANDS AND COASTAL PLAIN. (ADAPTED FROM ATLAS OF AMERICAN AGRICULTURE.)

regions just east of them. Fig 4 shows that the High Plains lie on the dry, lee side of the Rocky Mountains, from which they are separated by the rough Colorado Piedmont. The climate of both regions belongs to the dry, continental type, in contrast to the moist, continental climate of the Mississippi Valley states. According to records of the U. S. Weather Bureau, summarized in the Atlas of American Agriculture, the average annual precipitation throughout most of the High Plains ranges from 15 to 20 inches. In the larger part of the upper Mississippi Valley it is 30 to 40 inches, while 50 to 60 inches of rain fall on the lower Mississippi states. Even in March, April and May, which are moist months, precipitation on the High Plains is almost half what it is in the upper Mississippi

TABLE SHOWING AVERAGE WARM-SEASON EVAPORATION OF THE GREAT PLAINS. (AFTER ATLAS OF AMERICAN AGRICULTURE)[5]

Station (south to north)	Av. total Apr.–Sept. (inches)	Length of record (years)
Texas		
Amarillo	52.71	11
Big Spring	59.00	3
Oklahoma		
Woodward	49.52	4
Kansas		
Colby	39.91	4
Garden City	52.85	10
Nebraska		
Mitchell	38.45	7
North Platte	43.65	11
South Dakota		
Ardmore	38.59	5
Newell	37.00	10
North Dakota		
Dickinson	31.79	10
Hettinger	32.77	7
Mandan	33.30	5
Williston	33.11	8

Valley. Crop production west of the 100th meridian therefore requires either irrigation or dry-farming methods.

Low precipitation here is accompanied by notably high evaporation. The average warm-season evaporation, according to the Office of Biophysical Investigations, U. S. Department of Agriculture, ranges from 59 inches at Big Springs, Texas, to 33.3 inches at Mandan, North Dakota. Other data for points most of which are west of the 100th meridian are given in the accompanying table. It indicates that winds of the High Plains are drier than those of more humid areas to the eastward, and that the evaporation is greater to the south than to the north. Fig. 5 shows that, on the average, they also blow faster. These strong, dry winds intensify the aridity caused by light precipitation. They therefore limit vegetative cover, producing biologic as well as climatic conditions which favor the drifting of soil. When winds become very strong—Joel[6] records velocities of 40 to 65 miles at Amarillo, Texas—only soil which has very effective cover can resist the impetus to move.

[5] "Atlas of American Agriculture," U. S. Dept. Agriculture, 1936.

[6] A. H. Joel, U. S. Dept. Agriculture, *Tech. Bull.*, 556, 1937.

IV

Rainfall conditions soil movement, and it changes the soils themselves. East of the solid line in Fig. 1, precipitation exceeds 30 inches and evaporation is moderate, whereas to the west rainfall is lighter and evaporation is greater. In the former case, ground water carries dissolved lime carbonate away, producing what are called pedalferic soils. West of that boundary, lime accumulates a few feet or inches below the surface, forming deposits which locally are called "hard-pan," but are better known as caliche. Such accumulations are dominant, though not universal, and the soils which they characterize are distinguished as pedocalic. Such soils have lost less mineral matter by solution than have those of eastern humid belts. Where (or when) moisture is adequate, pedocalic soils support rich vegetation and contain much organic matter. Those which lack moisture have less organic material, but crops which some of them raise under irrigation prove the abundance of nutritious minerals in them.

Lugn[7] has studied the effect of wind upon the High Plains. He says:

> Loess materials at different times have been derived from exposed Cretaceous shale areas in Colorado and Wyoming, and also from Tertiary High Plains areas in Colorado, Wyoming, and western Nebraska. Recent dust storms have produced blow-out depressions, a number of feet deep and many acres in extent, in exposed Cretaceous and Tertiary formations, especially in South Dakota, western Kansas and eastern Colorado.
>
> Blow out depressions, still mostly undrained, as much as 40 or more feet deep and up to 2 square miles or more in extent, have been formed by wind action in the past, in the exposed Tertiary silty and sandy beds of the High Plains tableland areas of western Nebraska and adjoining areas. McKin has reported such depressions on the Pine Ridge table in northwestern Nebraska. The writer also has observed them on the Pine Ridge, on the Box Butte table, and on the Cheyenne table in western Nebraska, and on the high table south of the Lodge Pole Valley in Nebraska and Colorado.

Lugn[8] ascribes the red dust which fell at Lincoln, Nebraska, during the night of April 29, 1933, to the "red beds" of the Triassic and Permian of the Texas and Oklahoma panhandles, western Oklahoma and southern Kansas. The weather map for that date indicates strong and southwesterly winds in Kansas. Lugn also refers the dust carried by the storm of March 20 to 22, 1935, to southeastern Colorado, where eolian blow outs, sand dunes, and dust hummocks were forming. Finally, he says that recent winds in the Sand Hills Region have "drifted considerable quantities of fine and very fine sand eastward from the main area of sand hills out over the somewhat older true loess."

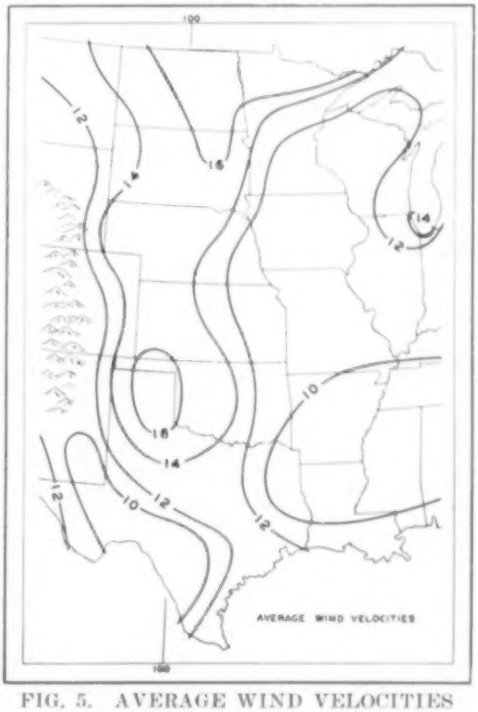


FIG. 5. AVERAGE WIND VELOCITIES AT 3 P.M., WHICH IS THE TIME WHEN WINDS GENERALLY ARE HIGHEST. (AFTER ATLAS OF AMERICAN AGRICULTURE.)

[7] *Op. cit.*, p. 163.

[8] *Loc. cit.*

Gila Pueblo, Globe, Arizona

FIG. 6. PEDOCALIC SOIL

EXPOSED IN A BANK NEAR ABILENE, TEXAS. LIME CARBONATE HAS ACCUMULATED IN THE SUBSOIL, FORMING THE WHITE DEPOSIT KNOWN AS CALICHE.

V

The recent dust storms were the natural results of deficient rainfall, depleted subsoil moisture and greatly reduced vegetation in a region of loose, dry, soil and strong, turbulent winds. These factors prevailed in both the northern and southern portions of the High Plains. According to the Weather Bureau,[9] there was an increasing deficiency of moisture at St. Paul during the 22 years preceding 1934. From 1926 to 1933, the average annual rainfall was three inches less than the normal amount.

No such prolonged period of moisture deficiency seems to have affected the southern High Plains, although in 1933 the annual precipitation at Dalhart, Texas, was 10.14 inches and in 1934 it sank to only 9.78 inches—slightly more than half the average over a period of 27 years.[10] In the first 10 months of 1936, rainfall in North Dakota was 50 per cent. of normal; in South Dakota, 52 per cent.; in Montana, 75 per cent.; in Nebraska, 68 per cent.; in Kansas, 69 per cent.; and in Oklahoma, 70 per cent.[11] These deficiencies reduced crop yields and also brought grave harm to the protective vegetation on soils.

In addition to their serious damage to the soils, dust storms have brought tragedy and loss to human beings. They have destroyed lives, created discomfort and illness among thousands, killed livestock, made highways impassable, ruined motors, damaged the contents of stores, factories and homes, buried orchards, fields and gardens, and disrupted commercial production. They also have brought darkness in mid-day, and have spread mud-rains far and wide over the country.

During March and April, 1935, there were 47 days on which visibility at Amarillo, Texas, was limited to 6 miles or less; during the majority of storms it was one mile or less and during six storms it was less than 500 feet (Joel). Fifteen storms lasted longer than 24 hours, and four lasted 55 hours or more. After the dust reached the higher levels of the atmosphere it was carried hundreds of miles. In eastern Illinois there were days when the atmosphere held so much dust that the sky was murky and the sun shone red. Some of this dust was carried even to the Atlantic Coast.

If such dust storms were to become the rule, they might have even other serious consequences. The interception of heat rays from the sun would retard normal heating of the earth's surface, reduce average temperatures, diminish plant

[9] C. E. Kellogg, U. S. Dept. Agriculture, *Misc. Pub.*, 221: 2, 1935.

[10] Joel, *op. cit.*, p. 62.

[11] G. K. Rule, Soil Conservation Service, U. S. Dept. Agriculture, Circular 430: 1, 1937.

growth and adversely affect weather conditions other than those of temperature.

Contrary to the common impression, dust storms of the 1930's are not the only destructive ones that have swept the Great Plains. The subnormal moisture conditions which set the stage for these storms occur in cycles. Climate has its pulsations on both small and large scales and over various periods of time. Any plan devised to offset wind erosion or soil drifting must consider cyclic changes. It must also take into account the fact that soil tillage over a period of years reduces the humus content, unless special treatment is given, while lowered humus content, in turn, reduces the moisture-retaining capacities of soils. In consequence of these changes, recent dust storms were more destructive and more wide-spread than they otherwise would have been. The dust storms of future dry cycles will grow even more destructive if reduction of the soil's humus continues.

Soils may vary greatly within relatively small areas and hence differ in their susceptibility to wind movement. Removal of the top soil may expose a relatively compact heavy subsoil which impedes erosion, but such material is likely to be less tillable and less productive than the soil that has been carried off. In dry regions, as we have seen, this subsoil commonly is caliche (Fig. 6), which may be as hard as some ancient limestone. Such material obviously is unsuited to the production of crops.

Uniformly fine, sandy soil favors wind transportation, especially after plowing. On the other hand, soils which consist of large aggregates of clay and silt, bound by clay-minerals such as beidellite, do not blow readily. Small aggregates of "fluffy" character, whose particles are as small as sand grains, but lighter, will drift very readily.

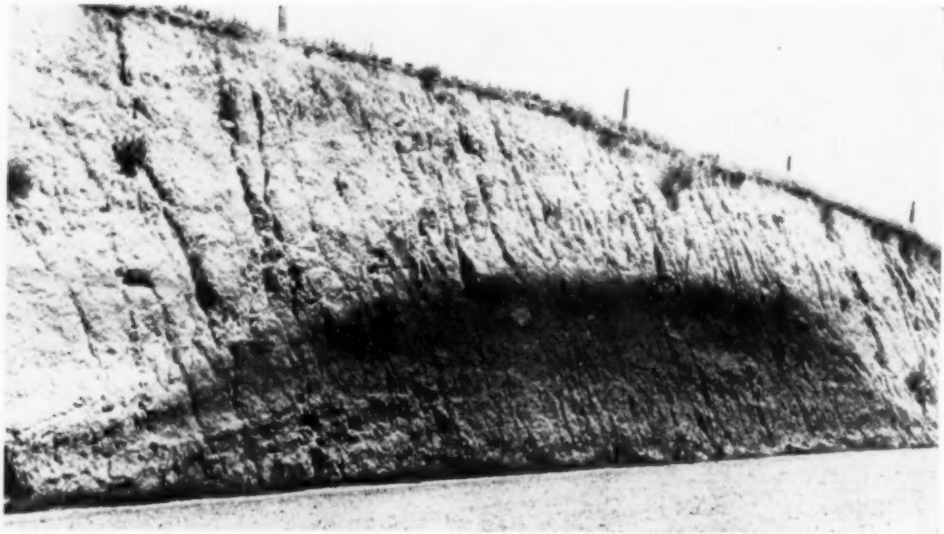
Topographic position is also a factor in wind erosion. Soils on windward slopes and brows of hills in rolling country are particularly vulnerable to attack, while deposition is favored on the leeward side. This combination of erosion and sedimentaion must eventually result in "spotted" agricultural conditions, reduced production and lowered land values.

VI

The geologist looks upon the problem of wind erosion in the Great Plains from a viewpoint which differs from that of the non-geologist. Every earth historian knows that dust storms of the Glacial Period were greater and more protracted than those of the 1930's. He also knows that certain definite conditions brought those storms to a close, introducing a long period of soil stability.

Fig. 3 shows the wide-spread distribution of the ancient, wind-blown dust deposits which are known by their Alsatian name of loess. In Nebraska alone there are 42,000 square miles of loess whose thickness in many places reaches scores of feet. This deposit extends into northern Kansas. Loess covers the western, southern and eastern portions of Iowa, and, at Council Bluffs, forms high hills on the east side of the Missouri River. A thin loess sheet covers the northern part of Missouri, becoming thick along the Missouri River. In Illinois, loess covers much more than half the State; it extends into southwestern Wisconsin, southeastern Minnesota, southern Indiana and the northern fringe of Kentucky. Other loess deposits follow southward along the Mississippi River to its modern delta.

This great sheet of wind-blown dust came from many sources. Some authors say that the loess of Nebraska and Kansas came from the Sand Hills region and from large river valleys, such as the Platte. Some of this dust floated onward to Iowa, Missouri and other states to the eastward, just as dust floated in the recent storms, but most of the loess in western Iowa seems to have been blown



A. G. Lugn, Nebraska Geological Survey

FIG. 7. LOESS NEAR GREELEY, NEBRASKA

AFTER THE LOWER LOESS (DARK FROM WEATHERING) WAS FORMED THERE WAS AN EPOCH OF MOISTURE AND WEATHERING. THEN DUST STORMS WERE RESUMED, DEPOSITING THE UPPER, LIGHT-COLORED LOESS.

from the Missouri flood-plains. That in eastern and central Iowa came from the Iowan drift-sheet and from valleys which received outwash from the Iowan glacier. The thick loess of western Illinois probably was blown from glacial outwash along the Mississippi, while that near the Illinois, Wabash, Ohio and other large streams apparently came from their wide, once-barren, aggraded valleys.

Loess deposits which lie at the surface are known to have older loesses beneath them. Fig. 7 shows an old loess deposit on which weathered soil developed before it was covered by a new bed of dust. Many similar exposures are known. They record several distinct epochs of dust storms and soil-drifting—all during the Glacial Ages, when man was not tilling the plains and prairies of North America.

What is the story of these ancient dust epochs? What caused their succession, their renewal and their final termination?

In answering these questions we must stress the fact that *the dust epochs have terminated*. No appreciable amount of material has been added to the loess of the Mississippi Valley since the last glacial epoch. The evidence of this is definite:

First, the last glacial drift, which extends southward to Des Moines, Iowa, as is shown in Fig. 3, is free from any cover of loess. The soils of the large area which it covers have been made from the drift itself. Loess deposits which surround the Des Moines lobe pass under the drift, as observers may see clearly in railroad and highway cuts.

Second, the loess of Iowa, Illinois, Missouri, and immediately adjacent areas has distinct and normal profiles of weathering. The normal thickness of topsoil is present, and below it are the usual traces of weathering, similar to the soils made from the last glacial drift. The development of such "soil profiles" in both loess and drift required thousands of years of stable conditions. The loess of these states, therefore, can not be of Recent Age.

The Glacial Period embraced both glacial ages and inter-glacial ages. To which does the loess belong?

The answer to this question lies in certain relationships which the loess of large areas bears to the main lines of glacial drainage and to certain drift deposits, as well as in fossil shells which are found in loess accumulations. Along those very broad valleys which received relatively fine outwash deposits of distinctive colors, the bordering loess has those same colors. It is also thickest and most sandy along the valleys, but becomes progressively thin and fine-textured away from them. These relationships leave no doubt that the loess was deposited while the valleys were being aggraded with fine valley-train material and while absence of vegetation from valley flats gave the winds a chance to pick up sand and dust. The lodgment of the sand and dust on the valley slopes, crests and uplands was due, at least in part, to vegetation of the open forest type, as is shown by the shells of pulmonate woodland snails which are found in the loess. This relationship of loess deposition to what once were barren valley trains—barren because they were being built—is constant and shows that the dust drifted and settled while the ice sheets were melting. This conclusion holds good for the Mississippi Valley from Minnesota to the delta, for the Ohio River along its lower course, for the Illinois River from the Big Bend to its mouth, for the Missouri River as far upstream as Sioux City and for such tributaries of the Mississippi as the Des Moines, Cedar and Iowa rivers. In most of these cases, loess on the eastern sides of valleys is much thicker than that on

FIG. 8. LOESS INTERBEDDED WITH GLACIAL DRIFT

IN THE BANKS OF FARM CREEK, NEAR PEORIA, ILLINOIS. THE ILLINOIAN DRIFT (A) IS OVERLAIN BY TWO DEPOSITS OF LOESS (B AND C), ABOVE WHICH ARE DRIFT (D) AND LOESS (E) OF THE WISCONSIN GLACIAL AGE. LOESS C WAS DEPOSITED JUST BEFORE THE WISCONSIN GLACIER ARRIVED; LOESS E, IMMEDIATELY AFTER ITS RETREAT.

western sides, indicating the dominating influence of the westerly winds, which still prevail in the Central Lowlands.

So much for the valley relationships of the loess, which show its sources and time of deposition in the Central States. We now may consider the meaning of its relationships to certain drift sheets which formed as glacial ice melted.

Calvin and others long ago discovered that the Iowan drift sheet, of northeastern Iowa, had definite and apparently genetic links with the loess deposits about its borders. There are stretches, scores of miles in length, where the loess begins abruptly, thins marginally in morainal fashion, is sandy, bears dune-like hillocks and grades progressively with distance into a fine-grained, thin sheet. In some spots, a thin mantle of loess covers the drift itself; where the basal part of this loess is unweathered, the underlying drift is unweathered also. In other words, there is definite evidence that such loess was deposited promptly after the Iowan ice melted.

The famous exposure along Farm Creek, near Peoria, Illinois (Fig. 8), shows that dust was drifting and settling during both the advance and retreat of the early Wisconsin ice sheet. There the first Wisconsin drift was spread upon unweathered loess which still contains evergreen wood and moss, the latter being specially common at the top of the dust deposit. The drift, in its turn was covered by loess before it had time to weather perceptibly. Beyond the limits of the drift, the upper and lower loesses merge—also without trace of an interval of weathering.

The point of all this—and there is more evidence were it needed—is that the ancient wind-blown dust of the Mississippi Valley states, generally known as the Peorian loess, is not interglacial but is glacial. It was picked up and deposited by strong winds which swept across barren stretches of fine, newly-laid outwash or silty drift. Pockets of dust are formed by the same means to-day near remains of steadily melting glaciers in Alaska and the northern Rockies.

Let us now consider the loess deposits formed on the Great Plains. Most glaciologists agree that the climate of the Plains was moist during glacial epochs, but that it was dry during interglacial epochs, just as it is now. Some authors therefore infer that the Nebraska loess was laid down in an interglacial epoch when ice was far away. This seems to be an error, for the latest Wisconsin drift area contains virtually no loess, and the yellow dust beds of Nebraska and states to the eastward are identical in age. We already have seen that the loess of Illinois was deposited during times of ice advance, as well as while nearby glaciers were melting.

Lugn[12] has shown that the Nebraska loess came from both the Platte Valley and the Sand Hills. The part which came from the Platte was derived from a wide valley train whose source was mountain glaciers of the Rockies; that train was not covered with vegetation because it was being built. Valley slopes, divides and uplands did bear plants, which caught and held drifting grains of dust. As for dust from the Sand Hills: it apparently was sorted out and removed during the interval of transition from the moist, glacial to the dry postglacial climate. This change apparently was so rapid that there was only a brief period between the death of protective plants which had grown during moist times and the arrival of drought-resistant species. During that break the Sand Hills were unprotected from the high winds that swept across them and continued eastward beyond the Missouri. When drought-resistant plants became established, wind erosion again became trifling. Since that happened, soils have formed extensively, proving

[12] *Op. cit.*

that relatively stable conditions prevailed until the white man arrived.

VII

The dust storms which we have just considered ended long before men brought farming and grazing into the Great Plains. Nevertheless, they allow us to draw four conclusions of value to them who now are attempting to mend the damage wrought by unwise use of the land:

1. Dust storms will occur in even a moist climate if broad areas of fine rock material, without vegetative cover, are exposed to the wind. This is true whether the exposure is due to natural causes or to the turning of the sod by man's plow. In the Middle West to-day, winds are removing soil from plowed fields, though more slowly than they take it from the dry Great Plains and the semiarid High Plains.

2. The general prevalence of a definite soil profile over the Great Plains, and even the High Plains, shows that their climate is not too dry for a general vegetative cover to develop if it is permitted to do so. Man's activities, carried on without a knowledge of or regard for the economy of nature, are responsible for dust storms of modern times.

3. In the High Plains, and under some conditions of soil and topography on the relatively low plains, the opposing factors are so nearly critically balanced that man must act with intelligence and skill if he is not to lose his greatest resource. If he follows proper methods, there is hope for the "dust bowl" of the High Plains as well as for the fertile Central Lowlands.

4. The short climatic cycles probably produced local but not wide-spread wind erosion under virgin conditions. But man's work is a new and powerful geologic factor which must be used with caution, especially during the drier parts of these minor climatic cycles, lest it result in soil-drifting and deposition on a nationally destructive scale.

A DRUG OR POISON?

By Dr. DAVID I. MACHT
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To the average layman the terms *drug* and *poison* denote two substances as absolutely separate and diametrically opposite as the poles. Many pharmacists and even physicians regard drugs and poisons as distinct and separate entities belonging to two different classes of chemicals. If one were to take a heap of drugs and attempt to classify them in containers to which the labels *Drug* and *Poison*! had been respectively affixed, he would experience the greatest difficulty in deciding to which group any particular substance belonged. As a matter of fact, modern pharmacology and experimental medicine have proved that there is no sharp line of demarcation between drugs and poisons. Indeed, every drug that is worth anything as a medicinal agent is also a poison; and, *vice versa*, almost every poison, under certain conditions, exerts a useful medicinal action and may therefore be regarded as a therapeutic agent. Here, as in almost every phase of human activity, the principle of relativity prevails.

The close relationship of medicament and poison is actually implied by our word "drug," which in its absolute sense denotes not only a remedy but also "dope." The Greek word *pharmakon* was similarly applied to both drug and poison. The ancient Hebrews employed the word *sam* for drug and also for poison and differentiated between the two by prefixing qualifying terms implying life or death. It was the *sam*, or "elixir," of life or the *sam*, or "elixir," of death. The Russian *yad* has the same double meaning, and in other languages the word for drug has a similar dual significance.

The most obvious criterion between a medicinal or poisonous effect of any substance is its dosage. That is the idea conveyed by the German word *Gift*, derived from the root "to give." The dosage is truly a most important factor denoting the difference between useful and harmful effects of chemicals. And so it came to pass that the ancients coined the Latin adage, *Dosis sola venenum facit*, "The dose alone determines the poison." The dose of a drug, however, is only one of many factors which qualify its physiological action on man and animals. In fact, so many conditions are now recognized as influencing the action of chemicals that no distinction is made between the sciences of pharmacology and toxicology. From the standpoint of modern science, the two subjects deal with complementary aspects of the same theme and are now generally comprehended under the one term, *pharmacology*.

Whether a given substance will act as a medicine or poisonous agent will depend on four sets of factors, elsewhere described by the writer as the "four dimensions" of pharmacodynamics. The first group depends directly on the subject—man or animal—to which a specific drug or chemical is given. Thus, for instance, belladonna is better tolerated by children than by adults, even though the dosage in relation to the respective weights is much greater for the young. On the other hand, various opiates and narcotics, even when administered in relatively small doses, are much more dangerous for the young than for the old. Again, various species of animals often exhibit an enormous difference in their reaction to a given chemical, and so the therapeutic dose computed from experiments on one or two species of lower animals—for instance, the guinea pig or rabbit—does not *per se* afford an absolutely reliable index to the correct dosage for a

human being. Such data obtained from lower animals usually serve only as *leads* which guide the careful pharmacologist in computing the smallest dosage to be administered to a human being and gradually increasing it to its most effective magnitude after cautious clinical experimentation.

The second group of factors depends on the drug itself. Of course, certain chemicals are intrinsically more active physiologically than others but, aside from that, here are to be considered the dosage of the drug or chemical, the concentration and other properties dependent directly on the drug itself. For instance, arsenic in small doses is a helpful blood tonic; in large doses, it is a horrible poison. Minute doses of such a salt as sodium cyanide, universally regarded as a poison, have actually been employed by Loevenhart and others as a respiratory stimulant because it has been shown that the cyanide ion, in very small quantities, is a stimulant to the respiratory center, while slightly larger doses thereof produce paralysis of the respiration and death. Every one mentally labels the cyanides, *Poison*! and justly so, yet it has been shown that even these compounds in suitable doses exert a useful therapeutic action.

To the third group of factors belong external conditions which may profoundly modify the action of drugs and chemicals and spell the difference between a therapeutic and a toxic effect. In this connection, the method of administration is often of great importance. Most drugs are administered by mouth; others, however, may be injected subcutaneously, intramuscularly and intravenously. Either of the two methods of administration may be chosen in some cases merely as a matter of convenience or at most in order to secure a quicker or slower action of the drug. When administered by mouth, however, many substances exert a physiological action entirely different from that which they evidence when given by injection. In other cases, injection of a drug may produce an entirely different pharmacological effect from that obtained by oral administration of the same substance. Thus, magnesium sulfate, which is ordinarily administered by mouth, is a harmless and very effective saline purgative. If a solution of magnesium sulfate be injected subcutaneously or intravenously, however, a paralysis of the central nervous system is produced because the magnesium ion, which is not readily absorbed from the gastro-intestinal tract, is absorbed after injection of the drug and poisons the nerve tissues. When given by mouth, epinephrine produces no physiological effect in a patient because it is destroyed by the digestive juices; when the same drug is administered by subcutaneous or intravenous injection, however, it rapidly effects a powerful stimulation of the heart, constriction of the blood vessels and dilatation of the bronchioles. Many other such external circumstances or conditions exert a profound influence on the physiological action of drugs and chemicals. Thus, for instance, it has been found that paramecia, placed in solutions of the fluorescein dye, eosin, or tetra-brom fluorescein, die soon after exposure to sunlight; while paramecia placed in similar solution but kept in the dark live on indefinitely. In such a case the ultra-violet rays potentiate the toxic action of the dye.

Meteorological conditions may also affect the action of certain drugs. The writer has recently shown that barometric pressure profoundly affects the potency of our best known cardiac stimulant, tincture of digitalis. For a long period, he made systematic records of barometric pressure and weather conditions in his laboratory and correlated these data with the results of his frequent assay of digitalis tincture. When a sudden and violent storm broke over Baltimore and the barometric pressure fell abruptly from 2 to 3 cm, it was found that the potency of digitalis, as tested by the cat method, was

increased. Similar findings pointing to a definite relationship between the barometric pressure and the toxicity of digitalis preparations were obtained by the writer and his colleagues in the assay of samples from a common stock at sea level and in the Blue Ridge and Rocky Mountains and in the Tyrolean Alps.

The importance of the fourth dimension of pharmacodynamics, or the time factor, which often plays a leading role in the action of drugs, has hitherto been little appreciated. One or two concrete illustrations will impress the reader with its consequence. The salts of quinine, administered by intravenous injection, are often a life-saving drug to patients affected with pernicious malaria. Ordinarily, a dilute solution of quinine hydrochloride is very, very slowly injected into a vein. Such a slow infusion of the alkaloid permits its distribution through the circulation to the various organs and tissues of the body without undue depression of the heart. If the solution of quinine be injected rapidly into the patients' vein, however, its concentration in the blood stream becomes so great that it depresses the myocardium, stops the heart-beat and induces death. In this case, the difference between the life-saving and the life-destroying procedures is marked by the difference in speed of administration of the drug. Even such an innocuous salt as potassium chloride, usually not regarded as a poison, may act in the same way when intravenously injected. Thus a 5 per cent. solution of potassium chloride, very slowly injected into a vein of a rabbit, cat or dog, will scarcely produce an untoward result because this particular salt is so rapidly absorbed from the blood stream and excreted from the kidneys, producing diuresis, that the characteristic depressant action of potassium for heart muscle is too slight to be noticed. When the same solution of potassium chloride is rapidly introduced into the circulation of the same species of animal, however, the concentration of potassium ions in the blood stream is sufficient to depress the heart muscle, arrest the heart-beat and hasten a lethal outcome.

The time factor plays an important role not only in connection with the speed or rapidity of administration of drugs but also in respect to the *time when* such chemicals are to be given, the duration of repeated doses, their relation to time of feeding and in connection with their acute and chronic effects. The time factor also plays a most significant role in connection with the phenomenon of *synergism,* or a greater potentiation of toxicity of two or more medicaments given at the same time than can be explained by the simple summation of their individual effects, because pharmacological research has revealed that two or more drugs, administered simultaneously or in rapid succession, may profoundly affect the action of each other.

The foregoing remarks indicate that there is no definite demarcation between the therapeutic and poisonous physiological action of any given chemical. The writer goes further, however, and states that the principle of relativity plays a role even when the toxic effects not of medicaments but of so-called poisons are compared. Most laymen, and even many pharmacists and physicians, designate various poisons as mild, violent, virulent, etc., without stating exactly what standard of comparison they use in classifying such substances. A chemical may be termed a violent poison because of its rapidity of action, yet on closer examination it may be found that with regard to lethal dosage it is much weaker than some other poisons. Another poisonous chemical may be very potent indeed with respect to the minute quantity required to kill an animal and yet not be regarded as a violent poison because its action is exerted over a comparatively long period. Failure to compare chemicals by some definite standard when describing and classifying their toxic effects has led to

much confusion and misunderstanding concerning the action not only of poisons but also of medicinal substances. The necessity for comparing chemicals by some definite standard is a subject worthy of considerable discussion. Its importance may be better illustrated perhaps by a brief description of portions of two researches recently conducted by the writer. One of these was a pharmacological study of cobra venom, the other an historical investigation concerning the drugs and poisons mentioned in Shakespeare's Romeo and Juliet.

The bites of venomous reptiles, often fatal, have always been regarded as very poisonous. From time immemorial the venom of poisonous snakes has been called a poison *par excellence*. Recently medical investigators have discovered that, far from being poisonous, minute doses of certain snake venoms actually constitute valuable medicinal agents. Some of these venoms have therefore been introduced into practical therapeutics. Thus, for instance, it has been found that small doses of crotalin, or the venom of the rattlesnake, have a sedative effect on patients suffering with cerebral convulsions. Rattlesnake venom has accordingly been employed therapeutically with considerable success in the treatment of epileptic seizures. Other investigators noted that the venom of the moccasin promoted coagulation of blood, and this venom in suitable doses has been employed with a measure of success in the treatment of certain forms of hemorrhage. Moreover, it has been claimed that the venom of the viper *Russellii* is useful in the treatment of hemophilia. Most interesting of all, however, are the recent studies published in France and America on the remarkable analgesic or pain-relieving property of graduated minute doses of the attenuated venom of the most deadly of all reptiles, the cobra (Naia). Much scientific research has been done with this venom by investigators at the Pasteur Institute, France, and a number of papers have been published by the writer in this country. These experimental laboratory studies have been followed by clinical observations which leave no doubt regarding the usefulness of suitable doses of carefully assayed cobra venom in treating the intractable pains accompanying inoperable malignant tumors and similar conditions. So the venom of the cobra and that of other snakes, for centuries regarded only as a poison, has proven in the light of modern scientific research to be a useful medicinal agent.

The student of classical literature will find that "Romeo and Juliet" probably contains more references to drugs and poisons than any other of Shakespeare's plays. The writer has made a rather extensive study of this particular play. In a lecture entitled, "A Pharmacological Appreciation of Romeo and Juliet," he has pointed out its wealth of historical material with regard to materia medica and Shakespeare's remarkable acumen in formulating certain pharmacological hypotheses or laws in striking accord with the findings of modern pharmacology. One of the best-known passages in Romeo and Juliet is that in which Romeo demands of the impoverished apothecary "such soon-speeding gear" as will quickly and most certainly dispatch him. Here the question should be raised, What was the poison which Romeo obtained and how quickly could such a drug effect his death? Pharmacological and historical research leaves little doubt as to the probable identity of the poison mentioned in that scene. According to some, it was the hemlock, *Conium maculatum*, but according to others, whose views are more in agreement with modern toxicological findings, it was monkshood or aconite. This poison was probably the most rapidly acting and potent poison known to the ancients. Indeed, its rapidity of action is specifically mentioned in "King Henry IV."

Learn this, Thomas,
And thou shalt prove a shelter to thy friends,
A hoop of gold to bind thy brothers in,
That the united vessel of their blood,
Mingled with venom of suggestion,—
As, force per force, the age will pour it in,—
Shall never leak, though it do work as strong
As *aconitum or rash gunpowder.*

Could crude aconite, taken by mouth, produce so rapid a death as that described in Shakespeare's play? The answer must be in the negative. Death within a few minutes could only be induced by injection of the active principle of aconite, or aconitum, which, of course, was not available at the time the play was written. Shakespeare therefore indulges in poetic license when he allows Romeo to die immediately after swallowing the drug. Poynter's story of Romeo's death is more in accord with scientific facts. Even more in agreement with the actual pharmacological findings is the account given in Gounod's opera, in which Romeo lives long enough to sing an aria to Juliet.

It is essential that the researcher making a rational comparison of the potency of two poisons reveal the exact conditions under which they are examined or tested. Obviously, this can be done only if one set of variables is compared, while all others are kept constant or carefully controlled. Here again, the element of relativity prevails and as in case of drugs in general four factors are to be considered: the first is the animal poisoned; the second, the physical and chemical properties of the poison itself; the third, the various external factors modifying its action; and the fourth, the element of time. In practical experimentation with different poisons it is especially necessary to control the species of animal employed, the dosage and concentration of the poison if given in solution, the portal of entry and the speed of administration. To illustrate the differences in potency of various poisons studied by such a scientific method, the writer has carried out a series of experiments with a number of well-known powerful chemicals according to the following procedure. Solutions of the poisons, usually, 1:10,000 (but in some cases more concentrated, *i.e.*, from 1:1,000 to 1:5,000), were slowly injected from a burette into the femoral vein of a cat kept under ether anesthesia. Each solution was injected at the rate of 1 cc every half minute. Blood pressure and respiratory movements were recorded on a slowly moving kymograph, while injections were continued until death of the animal. The lethal dose of each poison per kilogram weight of cat was then calculated. Comparison of the different poisons was made by the same procedure in each case. The poisons examined in this way were atropine sulfate, cocaine hydrochloride, aconitine hydrochloride, nicotine alkaloid, conium hydrochloride, potassium cyanide, sodium arsenate (1:1,000), cobra venom, rattlesnake venom, ouabain, ricin and abrin. The findings obtained are shown in the subjoined table. The results obtained with ricin and abrin are not recorded in the table because it was practically impossible to kill the animals with these substances by the procedure described above. While in point of lethal dosage they were poisons of extreme physiological activity, ricin and abrin required a long period of time to produce death.

The castor oil bean, *Ricina communis,* contains within its shell a substance called ricin, which does not ordinarily pass into the oil. While ricin is an extremely poisonous substance, the symptoms it induces do not usually set in until several days afterward, an incubation period being required for the complete action of the drug. Ricin is a protein-like body often termed toxalbumin, and its activity has been cited as greater than that of any other poison known. As little as 0.0005 mg per kg is fatal to a rabbit; that is, one part of ricin is fatal to two million parts of rabbit. Abrin, a drug obtained from the jequirity seed,

closely resembles ricin in its action. It is also very poisonous with respect to the infinitesimal dosage required to produce death, but abrin, like ricin, acts very slowly. Curiously enough, this particular toxin was once therapeutically employed for clearing the corneal opacities. Here is another instance of a dreadful, subtle poison, infinitesimal in its dosage, which is employed under certain conditions as a medicament.

In its action the highly potent hydrocyanic or prussic acid exhibits the converse of ricin and abrin. This chemical constitutes a classical example of a "violent" poison, denoting by that a substance very rapid in its action without referring to the quantity required to produce death. Death from hydrocyanic acid usually occurs in a few minutes. Its lethal dosage, however, generally given in text-books as 1 gr, or 65 mg, does not compare with that of a number of alkaloids and other poisons listed in Table 1. The fatal dose of hydrocyanic acid is from 3 to 5 grains or from 0.2 to 0.3 gram.

TABLE 1

LETHAL DOSE PER KILO WEIGHT OF CAT

Atropine sulfate	36.0 mg
Strychnine sulfate	2.50 "
Cocaine hydrochloride	10.0 "
Coniine hydrochloride	3.0 "
Nicotine alkaloid	1.3 "
Aconitine hydrochloride	0.28 "
Potassium cyanide	2.2 "
Sodium arsenate	187.50 "
Cobra venom	1.04 to 2.60 "
Crotalus ruber	20.0 "
Ouabain	0.10 "

Examination of the comparative table of lethal dosages obtained by the method described above reveals that by far the most important powerful poison in the list is aconitine hydrochloride, of which only 0.28 mg per kilo weight of cat was required for the lethal dose. Next in potency was the alkaloid nicotine. The lethal dose of this alkaloid per kilo weight of cat was found to be 1.3 mg. The writer has also shown elsewhere that, unlike the salts of other alkaloids, the salts of nicotine are somewhat less poisonous than the alkaloid itself. Furthermore, it is well to note that both aconitine hydrochloride and nicotine alkaloid are such penetrating poisons that a small quantity applied to the mucous membranes of the mouth or eye is rapidly absorbed, producing death. Of *Conium maculatum*, or hemlock, 3.0 mg per kilo weight of cat were required for the lethal dose, while that of strychnine sulfate was 2.5 mg. The other alkaloids of the series, namely, atropine and cocaine, when tested by the method mentioned above, proved to be much weaker. Ten milligrams of cocaine hydrochloride per kilo weight of cat were required to kill, while the minimal lethal dose of atropine sulfate was 36.0 mg. Sodium arsenate is a good example of a deadly poison not very rapid in its action. Animals poisoned with arsenic usually survive for several days. Even when the drug is injected into a vein by the method described, 187.5 mg per kilo weight of cat are required to kill. Of timely interest are the figures obtained with cobra venom, the lethal dosage in this case varying from 1.04 to 2.6 mg per kilo weight of cat. The variation in the lethal dosage was due to the action of different specimens of cobra venom employed. Cobra venom, like all other animal poisons, is not very stable and is affected by temperature, light and other physical agents. Rattlesnake venom is even more susceptible to heat than cobra venom. The venom of *Crotalus ruber* is twenty times weaker than cobra venom. From the standpoint of medicine and pharmacy, probably the most interesting figure in the foregoing table is that obtained with the glucoside ouabain. The physician and pharmacist do not regard ouabain as a poison because it is an invaluable heart tonic in extreme cases of heart failure, yet the lethal dose of this drug per kilo weight of cat is 0.1 mg, less

than half that of aconitine hydrochloride, the most potent poison listed in the table. Here is an excellent illustration of the rôle played by the element of relativity in our psychological conceptions of drugs and poisons.

The figures given above show the relative potency of different poisons when injected intravenously. An entirely different story was told when the same substances were administered to animals by stomach tube, a story which emphasizes the importance of accurately stating the exact conditions under which drugs or poisons are compared. Fluid extract of aconite, given to cats in doses of 3 cc per kilo weight, produced death only after twelve hours. The same dose, 3 cc per kilo weight, of fluid extract of *Conium maculatum,* or hemlock, produced only a mild depression from which the animal recovered the following day. Fluid extract of hyoscyamus, even in doses of 10 cc per kilo weight by stomach, produced only mild depression. The same results were obtained with 10 cc per kilo weight of fluid extract of belladonna. On the other hand, 2 cc of dilute hydrocyanic acid, introduced into the stomach of a cat weighing 2.5 kilo, produced death in less than three minutes. Inasmuch as hydrocyanic acid was not known to the ancients or until the development of modern chemistry, the tales of rapid poisoning with all kinds of dreadful concoctions to be found in classical literature, including Shakespeare, are to be read with reservation and with due concession to poetic license.

What lessons may be drawn from this brief discussion concerning the potency of drugs and poisons? It is established that there is no absolute or definite line of demarcation between the poisonous and medicinal action of any drug. Any drug is a potential poison and, conversely, almost every poison has a practical value and may be employed, under certain conditions, as a medicinal agent. The difference between the beneficent and harmful physiological effects of any given substance is determined by the four dimensions of pharmacodynamics or factors depending (1) on the animal or patient, (2) the drug itself, (3) various external modifying conditions and (4) the element of time. Again, it has been emphasized that the potency or virulence of a poison can not be adequately described unless the exact conditions under which it has been studied are definitely stated. A substance may be a very violent poison with respect to its dosage or the minute quantity required to kill and yet a comparatively mild one with respect to its speed of action. *Vice versa,* other poisons, which may be described as very powerful with regard to their rapidity of action, are found on closer study to be comparatively weak with regard to their lethal dosage. Moreover, our conceptions of drugs and poisons are often distorted by our psychological outlook and colored by our sentiments, especially with regard to practical and popular uses of medicinal substances. This is true not only of the layman but also of the pharmacist and physician. Thus cobra venom is universally considered a dreadful, rapidly acting, death-dealing poison, yet in suitable doses of properly assayed solution, it is a valuable therapeutic agent for the relief of pain. On the other hand, neither pharmacist nor physician thinks of ouabain, or crystalline strophanthin, as a poison because he regards this drug as a heart tonic, yet its lethal dose is actually smaller than that of aconitine, the most poisonous alkaloid known. Finally such a comparative study as the foregoing serves to emphasize the immense value of a training in scientific methods of thinking.

"To be or not to be—*that* is the question." Is the compound employed to act as a drug or is it perhaps to become a dangerous poison for lack of consideration of all the factors that play a role in its administration? The riddle has been solved at the cost of infinite labor and unending research.

COLOR IN FOOD, COSMETICS AND DRUGS

By Dr. HERMAN GOODMAN
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To introduce the subject of color additions in food, cosmetics and drugs in a few minutes I can but give highlights of the past, comments on the present and guesses for the future.

Color always appealed to man, and throughout history, color attraction led to experiment in berries, fruits, vegetables. There is a veritable natural spectrum in a vegetable platter. Your choice of strawberry probably depends upon the color idiosyncrasies of your inheritance in visible purple, and the volume of vitamin A you consume. No doubt the crafty Phoenicians sought to adulterate foods in their search for color, as the eastern peoples were long interested in the art. The Egyptians used pigments and we recall the range with which Cleopatra intrigued Anthony: green beneath her eyes, black to the eyelids, lashes and eyebrows, henna for finger and toe nails and for the palms. The ancient Hebrews were not far behind in their use of color for decoration of the person. Spices for food and incense were likewise tinted. The Greeks and later their Roman conquerors fell heir to a color-tinting secrecy which in turn reached the Byzantians and the other eastern people. The Koran of Mohammed refers to the material used for darkening the eyes under a name which persists to this day—Kohl. The art of tattoo and war paint may rightfully belong to this subject.

Color was the right of royalty, as witness the name "royal purple." The economic interpretation of history would impress us with the assumption that the search for the northwest passage or shorter route to the Indies was one for spices and for color. The pirates along the land route exacted too high tribute, and so Columbus discovered America, as the western hemisphere's continents came to be known.

Needless to say, all color was of natural sources as vegetable, animal or mineral. The production of such natural colors kept entire sections of people occupied and happy. But there must be change, and possible progress. So we come to the year 1838—one hundred gone—for on March 2 of that year, William Henry Perkin was born. While still a youth of 15, he hit upon the discovery of manufacture of mauve—the first artificial color—from coal tar. He was on vacation in his father's kitchen experimenting in fields which his elders dared not tread. Enough for us that what may have been an ignoble trial led to remarkable results. They upset the entire industry of natural color sources, and created a new, wider, bigger and possibly better world. Strange, too, that the first color drawn from the tar barrel should have been purple-royal purple of the ancient Phoenicians. Strange, too, that the boy's Easter vacation kitchen chemical trial should make it possible to bring purple to the lowliest of the subjects of royalty which once alone wore it.

Because Perkin did not throw away the ugly mess he had made in his unsuccessful efforts to create artificial quinine, the tar barrel has been forced to yield a part of its color horde. One can not name all the colors derived from coal tar. The methods initiated by the youth were improved upon, but to Perkin remains the glory.

We can not go into the development of Perkin's fundamental idea, but I can not refrain from introducing another boy into this story. Paul Ehrlich was two

years old in 1856 when Perkin uncovered mauve. He was a lad in his teens when he decided that chemistry was his life work. He displeased his teachers by interpreting all his work in terms of chemistry and chemical symbols, which the elders did not understand. Paul Ehrlich took the dye-stuff gifts of Perkin and founded a new attack on disease. He was the first to study the constituents of the blood, and distinguished the members of the white blood cell series. He discovered the acid-fast nature of the tubercle bacillus recently discovered by Koch. Incidentally, he acquired tuberculosis during his experiments. Vital staining was stressed by Ehrlich. He named the gonococcus. He advanced the side chain theory so useful to future experimentation.

We digress a moment to show the growth of the boy Paul Ehrlich. He digressed from experimental work with color. He evaluated and standardized diphtheria antitoxin and studied the oxygen requirements of the living organism. The side chain studies culminated in the discovery of the serological reaction for syphilis. Wassermann publically proclaimed that had it not been for Ehrlich's work on the side chain theory of immunity, he never would have hit upon the reaction. We mention sadly that experimental work on therapy of cancer failed despite the fields of thousands of experimental animals and painstaking endeavors.

We return to the colors or dyes which Ehrlich brought to relieve human suffering. About 1906, Ehrlich began his experimentation with dyes beginning with atoxyl. He passed through additions and modifications. After 606 experiments, the dye we know in the United States as arsphenamin—discovered as salvarsan—and chemically, dioxydiaminodiarsenobenzol—was made and used successfully in animals. The dream of *therapia sterilisans magna* remained a dream, but the dye formed by Ehrlich from the self-same tar barrel as gave Perkin his purple is no dream. Other recent dyes found useful in treatment of disease are not dreams either, but 606 stands in a class by itself.

The search in the tar barrel has resulted in many kind products. The healing antiseptics, as the chloramines; the complicated mercury added radicals to chrome carriers—for these we are duly thankful. We accept with gratitude odors which surpass those of nature's garden-colors, the like of which never were seen prior to the studies of Perkin. We use coal-tar products for the alleviation of pain; for anesthesia; as substitutes for rare or otherwise costly natural products. Color—all color.

On the other side of the ledger we have the unkind products. Explosives, poison gas, these and a host of by-products which upset natural economy between nations and favor the technicians—are likewise products of the same tar barrel. The less said of these the better.

To-day, then, no matter what your field of endeavor—no matter what your major interest—you are influenced by the discovery of the first coal tar color. I defy you to touch anything within reach of your hand which is not influenced since your grandfather's time because William Henry Perkin uncovered the royal purple. The ink which flows from the pen, the color of your tie, the saccharin in the gum or candy pellet you still nurse between your jaws—and on and on—each has been changed because Perkin went home on a vacation and did not throw away the evil result of an experiment.

How can one guess what to-morrow will bring forth from the tar barrel. It is claimed that after 606 we had 914, but that hundreds of other chemical combinations remain to be made which the color genius of Ehrlich wrote on paper. One of them may further revolutionize the healing art. A student of to-day may yet stand forth with still weightier dis-

coveries than the two youths we have named—Perkin and Ehrlich. That scourge of the human race, cancer, may yet yield to coal-tar chemical miracles.

We must mention briefly that coal tar has been offered as a cause for cancer. Certain chemical quotients of coal tar applied to the tail of the experimental rat have already produced cancer reactions. Certain coal tars are known to produce other irritations not as serious as cancer but unsightly and undesirable. We rarely have skin and mucous membrane irritations from the color additions in food, drugs and cosmetics. We have the rarity of lip stick dermatitis which is so welcomed by the reformers and prohibitionists of cosmetics. We likewise have the unfortunate general reactions of certain individuals to other coal tars taken by mouth to relieve disease. In medical practice, we group these rare ill results under the term of "allergy" which is mysterious until defined as altered reactivity. Then we know that the name allergy doesn't explain anything! It only gives a Latin name and places the whole matter into the oblivion of a pigeon-hole. But allergy doesn't remain pigeon-holed for long. Each new piece of evidence drags the entire matter forth into the light of court of law if not into sunlight and rational laboratory procedures.

There is no explanation for allergy which really explains. We have discussed the questions of allergy often, and the matter remains one for individual opinion.

The interrelationship between dermatitis and allergy is also one of individual opinion, although subject to some experimental study in addition to philosophical discussion. Coal-tar colors may act in the production of each. A generalized exfoliation of the skin of the recipient of a dose of arsphenamin is sufficiently terrifying and illness-producing without burdening patient or physician with the added excitement of classification—dermatitis or allergy. It is back to altered reactivity. Fortunately, much arsphenamin is given without the dermatitis. But it is an example of color injury to man.

Color adds beauty to life; coal-tar chemistry foundation of color adds to life itself except when it takes life. But perhaps there has been compensation. Although it is true enough that had there been no coal-tar chemistry, we may not have had a world war, it is equally true that had we not had salvarsan, the world made safe for civilization may have been victim to syphilization!

A SOLUTION FOR LAND TRANSFER DIFFICULTIES

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THE methods prevalent throughout the United States for the determination of title of real property are so cumbersome and inexact that in recent years many persons whose work has brought them in contact with real estate transfers have given considerable thought to their improvement. The methods not only unduly increase the expense of transfer of title but frequently seriously delay the consummation of sales. With such methods in use the transfer of real estate involves difficulties never encountered in the transfer of other forms of wealth. Where property has changed hands frequently within a short time or where many years have elapsed without a recorded transfer, titles often become hopelessly involved. Land surveyors, title examiners and realtors are in agreement that these methods should be completely revised. In an effort to mitigate some of these troubles many state legislatures have enacted or are considering the Torrens system of land registration. This system, to be discussed later, offers a splendid solution to some of these difficulties; but while such a system is excellent as far as it goes, it can never attain the objective desired unless other important changes in the methods accompany it.

Under the present methods of proving title, it is imperative that *two distinct studies* be made of conditions affecting the parcel of land in question. The first study is a search covering many recorded documents, which is colloquially known as a title search, tracing the title from its source and examining the records for liens against the property. Such a search is time-consuming and expensive, and unless made with great care and good judgment, errors frequently occur.

The second study, of equal importance with the first but seldom given much thought, is the necessary careful instrumental examination of conditions on the ground. It is essential to determine the positions of landmarks and established boundary lines actually existing, and to compare the positions of such landmarks with the descriptions of the properties found in the recorded deeds. Such an examination enlarges in scope as the various partitions of land are studied while working back to the first partition from the original tract. It calls for a complete and accurate survey of existing boundary marks over a considerable area surrounding the property in question as the location of each boundary line is dependent on the location of others in the neighborhood. Not only must the location and shape of the parcel be judged by its own description, but its size, location, and shape with respect to that of neighboring properties must be carefully considered. It is obvious that such an examination parallels very closely a search of title, except that due to the restrictions of geometrical requirements, a thorough study of adjoining and surrounding properties is also required. Due to the necessity for this comprehensive program of accurate field surveying, requiring the services of several trained men and usually covering the entire area of the original tract, the expense of a proper examination of this kind is altogether too great to be charged against one particular parcel of land.

Obviously, the title search and land examination necessary for one property is adaptable, with slight modifications, to all properties within the original tract. For this reason it is customary for organizations engaged in frequent title

search to maintain a list of abstracts of title and for land surveyors to keep files of survey records referring to each original tract. When such records have been collected the cost of obtaining them can be spread over all the examinations and surveys made throughout the area, and each client receives the benefit of the complete work.

But unfortunately no legal recognition is given to such an arrangement, and therefore no control exists for the regulation of this work. The individual is not protected against spurious surveys which appear to be made with care, but in fact are not based on the necessary complete investigation described and which because of this lack of thoroughness are offered at a lower cost, than would be charged for an accurate and complete survey made by a reputable surveyor. Also in the search of the documents and in the examination of the ground, personal opinions must be relied upon. It is not clearly realized that although surveying is an exact art, in locating land boundaries so many inconsistencies arise that judgment is more important than skill. Both the title examiner and the land surveyor are forced to make assertions to their clients as to what they believe would be the result of a court decree. The client demands this, as the cost of such a decree would be out of all proportion to the matter involved. Also, when either the examiner or the surveyor is of the opinion that a court decree is necessary, a cloud is cast on the title of the property in question, and due to the fear of loss of title or the excessive costs of court procedure, no steps are taken to clear the title and the parcel may become practically without a market and its value may deteriorate as the owner does not wish to risk improvements on it. A clouded title for a parcel of land in a locality also reduces the value of adjacent property as its ultimate disposition is usually a matter of conjecture.

If legal recognition were immediately given to the decisions of the examiner and the land surveyor (after proper judicial review), and the actual title certified by the court with reference to a definite, legally recognized system of marking the boundaries, the chief cause of clouded titles would be eliminated.

The Torrens system, which has been adopted in one form or another in some twenty-two states and territories, provides a simplified and business-like method for the establishment of titles and eliminates repeated searches of recorded documents. To quote from a "Manual of Torrens Procedure" by R. G. Patton and C. G. Patton, " 'The principle of this system is the registration of the title to land instead of registering, as the old system requires, evidence of such title' Chief Justice Start in State vs. Mitchell, (1902)85 Minn. 437, 89, N.W." In a word, the Torrens system provides for a definite court procedure which results in a court decree granting a certificate of title upon which all subsequent changes affecting the title of a parcel must be recorded. The certificate thus becomes sole and complete evidence of title and future title searches are confined to mere examination of the certificate, together with certain checks of recent tax liens.

It must be noted, however, that the Torrens system eliminates only the difficulties and inaccuracies of the title search, it does *not* eliminate the necessity for an extensive examination of the ground. A word of caution would therefore seem appropriate as a warning to those state legislatures considering the adoption of the Torrens Law. Historically the method was developed from a system of ship registration which had been found to be most successful. But the great difference in this connection between ships and real estate lies in the fact that it is a simple matter to identify a certain vessel and to prove its existence, but it is very difficult indeed to identify and determine land boundaries, or to even prove that a parcel of land exists at all.

Astonishment has often been expressed that persons will frequently avail themselves of the services of a title company rather than rely upon the Torrens system, backed as it usually is by a guarantee of title by the state and an assurance against loss provided by an insurance fund made available from the state treasury. The reason becomes clear when it is understood that the title company offers a prospective client a far greater service than is provided by the usual Torrens Law. A good title company not only maintains accurate title record information but employs, or retains, competent surveyors whose office records include complete survey information in the areas in which they work. The client is assured that when a title company offers a guarantee of title, proper documentary search has been made and a complete examination of the ground in the light of the descriptions contained in recorded deeds has been made by a competent surveyor.

The above-mentioned defect in the Torrens system has so handicapped its operation that many regard it with suspicion or scorn. It has even been attacked as a raid on the state treasury for cheap title insurance.

In the light of the foregoing let us consider the necessary elements of a proper system to prove title:

(1) All documents bearing on the title must be studied by a competent examiner. He should weigh the evidence of such documents, assure himself that nothing has been overlooked and make a report of his findings.

(2a) A complete preliminary instrumental survey must be made by a competent land surveyor based on *enduring legally recognized monuments* and referencing all existing landmarks to these monuments.

The chief consideration in the above requirement which is most difficult to obtain is the durability of monuments. If a monument is to be enduring it must be part of a system of monuments, the relative positions of which have been determined by precise surveys. In other words, it must be part of an accurate, well-designed system of survey control. Under these conditions any monument in the system can be reset when disturbed or lost by a survey extended from any two other monuments in the system. If a city survey exists, this system will serve, but by far the best solution is to connect the monuments with the fundamental triangulation net of the U. S. Coast and Geodetic Survey. When local surveys are tied to these marks, such survey can be reproduced precisely with the certainty that the original initial point was used. The State Systems of Plane Coordinates recently introduced by the U. S. Coast and Geodetic Survey provides a means of facilitating such connections.[1]

(2b) The land surveyor should weigh the evidence produced by his survey in the light of descriptions in recorded deeds, assure himself that all the evidence has been gathered and that the survey is made in accordance with recognized standards, and make a report of his findings.

(3) These reports should be reviewed by competent state officials, preferably by a judge familiar with such matters, and an experienced surveyor-general. Any further evidence thought necessary by the reviewers should be obtained.

(4) The matter should then be made the subject of a court proceeding to which are cited all interested parties. The court should issue a decree stating the condition of the title and a description of the boundaries with respect to the enduring

[1] The system of plane coordinates established by the U. S. Coast and Geodetic Survey for New Jersey was given official approval by an act of the legislature of that State in 1935, and at the present time bills of similar purport have been introduced in the legislature of other states. Such a law was enacted recently in Pennsylvania and in New York a bill of this kind is awaiting the governor's signature.

monuments previously described in paragraph 2a.

(5) A certificate should be issued as a corollary to the decree which would be sole evidence of title and location of the boundaries. It should be the duty of the court to see that this certificate be preserved and nothing affecting title or position of boundaries should be recognized unless recorded on the certificate.

In other words, the Torrens system handled by a special Land Court which includes the office of a surveyor-general, together with the use for property description of a legally recognized State Plane Coordinate system, is the goal to be reached.

The beauty of this system lies in its finality. By its legal approval of the findings of the examiner and of the findings of the surveyor, and the recognition of boundaries and monuments used, it fixes title and location of a parcel of land once and for all time and it removes forever the necessity for repetition of this work. The costs of such a system could therefore be fairly charged, not only to the original owner but also to subsequent buyers of this registered land, thus making an equitable distribution thereof. The value of such property is so enhanced by this system that future owners would be glad to pay a transfer tax for the benefits obtained.

In the State of Massachusetts, a close approximation to this system has been reached. In this state, a Land Court, consisting of three judges who sit in various parts of the Commonwealth, has been instituted with jurisdiction over nearly all forms of litigation having to do with real estate. The judges of this court, due to their specialization, have become experts in real property law. This is a great advantage in itself as a large percentage of such actions are uncontested. When this court was established, an able land surveyor was appointed as an assistant to the recorder and his advice and counsel has resulted in sound practices with respect to the location of the property boundaries.

He reviews the work of the surveyor, who makes the original determination of survey data and is responsible to the court for the accuracy of the survey together with the location of the lines shown. He is careful to see that sufficient information has been obtained and that no pertinent fact has been omitted. Thus when the court makes its decree it has before it not only complete information obtained by the title examiner but complete and accurate survey information as to the location of the various property lines and landmarks. When a court decree is issued, the engineer of the court is responsible for the proper marking of the property on the ground so that the lines decreed can be located at any time. He is careful to see that the marks are permanent and properly interconnected by surveys so that each becomes a witness to the other. When state coordinate monuments are available, survey connection is made with them which still further increases the permanence of the decreed lines. In his office a scale drawing is made up for each parcel showing the decreed boundaries and complete survey information including that for landmarks. This drawing becomes a part of the certificate of title and assures the owner not only of title but of the location of his holdings.

It is suggested that when an act establishing a Torrens system is under consideration, the pattern of the Massachusetts law be adhered to, modified to include the appointment of a surveyor-general, who shall advise the court in matters relating to facts determinable by instrumental surveys and be responsible to the court for the proper marking of the property on the ground by a sufficient number of enduring monuments, together with the elimination of conflicts caused by geometrical requirements.

ORGANIC THEORY OF THE STATE

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I

It is apparent to most thoughtful people to-day that the political and economic machinery of American democracy must be overhauled, if our democratic institutions are to survive and are to meet the needs of the future. Economists, sociologists and practical politicians, however, are far from being in agreement as to the type of revision best suited to American needs. The greatest handicap at the present time is the lack of a basic philosophy on which all can agree. I, therefore, venture the opinion that the most reliable guide to an impartial and successful overhauling of our democratic institutions would be the political ideals deduced from the economic perfections of the human body.

There is nothing new or revolutionary in this suggestion. It would merely mean renewed faith in an ancient religious or philosophical concept, the modernization of an ancient biological doctrine and its readoption as an impartial yard-stick in social engineering. This ancient philosophical concept is known technically as the functional or organic theory of the social order.

II

The organic theory of the state pictures the politico-economic state as a living organism, a large-scale manifestation of the same basic biological laws as those studied to-day by means of the microscope and test-tube. Thus pictured, political, economic and social institutions become literally organs of the body-politic or functions of the economic order, in much the same way that the heart is an organ performing a necessary function in the human body.

If all this is true, it logically follows that translation of social problems into homologous problems in human pathology or human physiology would automatically suggest ideal solutions of these problems, solutions planned by creative intelligence or, in more modern language, solutions perfected by ten million years of organic evolution.

In somewhat different language, the organic theory of the state assumes that social planning is a biological problem, not a mere question of engineering efficiency. In fact, the theory even suggests that biological efficiency and engineering efficiency may be incomparable with each other. The organic theory further assumes that the best guide to social reform would be the creative intelligence or evolutionary wisdom manifest in the solution of identical problems in the human tissue-complex.

Historians tell us that this theory and method of application had their origin in Greek philosophy, four centuries before the beginning of the Christian era. This pagan theory was afterwards translated into Christian terminology. Thus translated the organic theory of the state became part of the official doctrine of the medieval Christian Church. During the thirteenth, fourteenth and fifteenth centuries, for example, it was applied by such leaders as Thomas Aquinas to the solution of the major political problems of that time. Reasoning from the erroneous anatomical and physiological knowledge of their time, they deduced the doctrines of the "divine rights of kings" and of the superiority of the church over the civil authority of the state.

III

No one will deny that modernization and readoption of this ancient philosophy would be of academic interest. It, how-

ever, would be without practical value, unless it can be shown that application of the biological yardstick suggests new ideas or new points of view in political science not readily drawn from historical data or statistical evidence. In order to test this possibility, I have selected an extremely simple biological problem, comparison of the American theory of state rights with the physiological ideal.

The American Constitution makes provision for two types of national organization. First, there is the normal or peace-time integration of the states, a union or partnership of free and independent states, each state retaining full sovereignty over all problems arising within its own borders, except such powers and duties as are formally delegated to the national government. Second, there is provision for an emergency or war-time integration, an automatic change of our union into a totalitarian state under the dictatorship of the national political machinery. On the passing of the emergency this emergency totalitarian state automatically reverts to a peace-time democracy.

IV

In the human body there are provisions for the same two types of organization, but with one essential difference. The peace-time democracy and war-time dictatorship do not alternate with each other as in our national government, but are operative simultaneously and are very closely integrated with each other. The skeletal muscles, for example, and other parts reacting directly with or against external environmental factors have lost their individual autonomy and are under the constant dictatorship of the central nervous system. The essential internal or domestic functions of the body, however, have to a large extent retained their individual autonomy and are organized as a peace-time democracy, with minimal dependence on centralized neurologic authority.

This, however, is far from being a union of free and independent organs. It is essentially a partnership of interdependent organs, in which each organ delegates part of its local sovereignty to related tissues in other parts of the body. Thus, the heart, removed from the animal body and attached to a proper perfusion apparatus, will automatically adjust its rate, volume and strength of contraction so as to meet its own minimum needs, through the coronary circulation. Under these conditions the heart exercises full sovereignty over all problems arising within its own borders.

Returned to the animal body, however, part of this cardiac sovereignty is delegated to the neighboring tissues of the thoracic cavity, and part even to more distant organs of pertinent function. Thus, part of cardiac control is vested in the far distant kidney, which under certain conditions, in order to insure its own circulatory needs, can cause the circulatory system to double its normal work. Recent investigators have shown that the resulting arterial hypertension or partial dictatorship of the kidney over circulatory functions is not mediated through the central nervous system, but is effected by means of some wholly unknown decentralized chemical hormone.

V

In place of attempting to describe this integrating pattern in greater detail, it may best serve our purpose if I should outline the necessary revisions in our present political machinery, if the United States were reorganized to conform with the physiological ideal. Thus reorganized, California, for example, would still retain full sovereignty over all problems arising within its own borders. Its executive, judicial and lower legislative machinery would remain unchanged, except that some type of proportional representation instead of our present majority rule would be more nearly in accord with the biological pattern.

The California senate, however, would be radically revised. First, state senators would not be elected, as at present, to represent geographical areas, but would be selected or appointed by the major cultural and economic groups of California as a whole. Second, the state senate would be enriched by one or more regional senators, elected or appointed by each of the neighboring states of the Pacific Slope, with a smaller number of senators selected by more distant states or groups of states of similar cultural or economic interests. Finally, California would receive one or more environmental senators from Canada, Mexico, South America and the Orient. In return, California would elect or appoint one or more state senators to represent its own interests in the higher legislative branches of every other major state of the American Union. The result would be a union of free but formally interdependent states, the interdependence being symbolized by interlocking legislative machinery.

VI

A biologist, of course, is not concerned with the political feasibility of any plan suggested by the physiological model. The above plan, however, illustrates the type of ideas drawn from modern biological analogies. Incidentally, it would solve a controversial question of the present time—what to do with our state senate. Evolutionary wisdom rarely discards a superfluous organ, provided it is possible to transform it into a useful function.

Now picture a further evolution of this California plan. The United States Senate changed to represent the major cultural and economic groups of America as a whole and enriched by one or more environmental senators appointed or elected by Canada, Mexico, Brazil, Argentina, the principal European powers and the Orient. In return, two or more American senators sitting in the House of Lords and in the equivalent councils or legislative branches of other major nations. An international physiological integration, though interlocking legislative machinery, making superfluous the present biological monstrosity the League of Nations. Until some such form of decentralized international integration is worked out, world peace will remain a biological improbability.

VII

The limits of this paper will permit only brief mention of one or more of the more complex social problems for which logical and consistent solutions can be suggested by the biological yardstick. One of the most interesting of these is the problem of capital and labor. This may be studied by means of analogies with capitalistic tissues, labor tissues and consumer functions in the human body.

Two facts are soon apparent from such a study: (1) Both the capitalistic system and the profit-motive are endorsed by evolutionary wisdom, and (2) the present American, German, Italian and Russian systems of industrial relationships are all equally at variance with the biological ideal. The nearest approach to the physiological ideal thus far developed in any modern civilization is the Decentralized Cooperative Democracy now in course of apparently successful evolution in Scandinavia.

An experimental pathologist, however, would emphasize certain inherent dangers in the cooperative movement, if planned or allowed to develop in such a way as to reduce individual competence and initiative. Physiological cooperation of human tissues is essentially competitive in nature, constantly training the aggressive efficiency of individual cells, organs and functions. Non-competitive cooperation, however, can be produced under certain experimental conditions. Such parasitic cooperation, however, inevitably leads to atrophy of one or more of the non-competitive tissues.

THE CAUSES OF CANCER[1]

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THE development of cancer in an organism consists in the transformation of certain previously normal adult or embryonal cells into cells which grow more actively and in some cases also carry out more active movements. They do not, therefore, respect the boundaries of the surrounding tissues with which under normal conditions they are equilibrized in a definite way. These transformed cells may also invade vessels and thus cause metastases at distant places. At the same time they undergo certain alterations in their metabolism, among which the changes in carbohydrate metabolism have perhaps been best studied. As far as we know, cells which have once undergone this change always remain cancerous; they may be destroyed or otherwise eliminated, but they do not ever return to their normal mode of life; they remain in an over-active, stimulated condition as long as they live.

The cancer problem concerns, then, the question as to why cells undergo these changes in their mode of growth and in metabolism. A complete answer would presuppose a complete understanding of the processes of normal growth, normal tissue movements, and normal cell metabolism. In the wider and deeper sense the cancer problem is therefore a problem of tissue physiology and will progress concurrently with the latter science. But if we restrict the cancer problem to a study of the conditions under which normal tissues undergo these abnormal and apparently irreversible changes, our knowledge is more definite, although even then certain important defects in our knowledge still remain.

In order to present the main facts known concerning this transformation of normal into cancerous tissue, we shall cite a few typical examples of animal cancers in which the causes of cancerous growth have been more thoroughly investigated. It has been shown that the development of carcinoma of the mammary gland in mice can be prevented by eliminating at an early period, by means of ovariectomy, the action of ovarian hormones, in particular, oestrin, on the mammary gland tissue. The earlier in the life of the animal this hormone action has been removed, the larger is the number of female mice in which the occurrence of cancer is prevented. We may therefore conclude that oestrin is largely responsible for the development of mammary cancer in mice; this hormone apparently acts by inducing rhythmic growth processes in the mammary gland tissue during proestrus and oestrus, and during pregnancy. This conclusion can be confirmed by injecting large amounts of oestrin into animals over long periods

[1] It may be of interest to compare with this paper on "The Causes of Cancer," a paper by the writer on "General Problems and Tendencies in Cancer Research which appeared in *Science*, March 3, 1916, Vol. 43, p. 293. References to the literature up to the year 1936 may be found in an article by the author on "The Interaction between Hereditary and Stimulating Factors in the Origin of Cancer" in the *Acta of the International Union against Cancer*, 2: 148, 1937. More recent papers to which reference is made are the following: Peyton Rous, *Am. Jour. Cancer*, 1936, Vol. 38, p. 233; R. A. Moore and R. H. Melchionna, *Am. Jour. Cancer*, 1937, Vol. 30, p. 73; J. Furth and C. Breedis, *Archives of Pathol.*, 1937, Vol. 24, p. 281; J. J. Bittner, *Jour. of Heredity*, 1937, Vol. 28, p. 363; V. Suntzeff, E. L. Burns, Marian Moskop and Leo Loeb, *Am. Jour. Cancer*, 1938, Vol. 32, p. 256.

of time; under these conditions the number of mice which develop breast cancer increases and even male mice can be made to acquire this type of cancer.

But there are still other factors active in the development of mammary gland carcinomas. In addition to the stimulating action of the hormone a second factor comes into play, which is transmitted by heredity from generation to generation in certain families and strains of mice. In some strains this kind of cancer almost never occurs, while in others every female mouse becomes cancerous if it reaches a given age. It has been maintained that a single recessive gene is responsible for the hereditary transmission of this and other tumors. However, this is not the case; it has been shown that the hereditary tendency of the mother to acquire mammary gland cancer is more important in determining the development of mammary gland carcinoma in the offspring than the hereditary constitution of the father, and according to the recent experiments of Bittner there is some indication that the milk of the mother transmits some kind of cancer-inducing factor to the child. In strains with a high hereditary cancer incidence the milk of the mother seems to contain this factor more often, or in a more effective degree, than in strains with a low cancer incidence.

However, this statement applies only as far as cancer of the mammary gland is concerned. Mice may also, as a result of long-continued injections of oestrogenic hormones, develop precancerous and carcinoma-like lesions in vagina and cervix, especially at the portio; in this case the hereditary factors which help to determine the formation of mammary gland carcinoma are lacking or different; oestrogenic hormones evidently induce the development of cancer in those organs in which they call forth long-continued or often repeated growth processes. At the time of each oestrus, oestrogen induces proliferative changes in mammary gland as well as in vagina and cervix.

But in addition to carcinoma, sarcoma may develop in some mice which have been injected with oestrogenic hormones over long periods of time and this usually occurs near the place which has been chosen for the injections. Sarcoma formation may, however, be induced also by the injection of substances which do not cause carcinomatous growth in the mammary gland and vagina, such as luteal hormones and even solutions which contain neither ovarian hormones nor one of the common cancerigenic chemical compounds. The factors underlying sarcoma formation are therefore less specific than those causing carcinoma in mammary gland or vagina and cervix. Whether it is the mechanical injury caused by the injection of the fluid and the regenerative growth processes which follow this injury, or whether chemical factors of a less specific nature are involved, is as yet undecided. It is well known that long-continued irritation of certain tissues leading to often repeated attempts at wound healing, and therefore to regenerative growth processes, may in the end induce the development of cancer. We may then state that often repeated regenerative growth processes and hormones may cause cancer.

But there are still other kinds of stimuli which have similar effects. Thus certain metazoic parasites may change normal tissue into cancerous tissue. Bilharzia infecting the human bladder may here first produce a benign papilloma, and this gradually passes into carcinoma. In general, benign tumors—exclusive of malformations or of the results of inflammatory alterations—in particular various types of adenoma, papilloma, and probably also myoma, fibroma and angioma, may be considered as potential transition states between normal tissues and cancers, and all types of such transitions may occur although, as a rule, these

growths do not undergo this extreme change.

There are metazoic parasites which may cause cancer in the liver of the rat, and still others have been held responsible for the development of cancer in the fore-stomach of rats. The active stimuli in these cases are presumably chemical in nature, but the participation of mechanical factors can not be definitely excluded. Roentgen rays, radium and ultraviolet rays also may produce cancers, carcinoma as well as sarcoma; which of these two kinds of tumors is produced depends largely upon the tissue upon which these agencies act. We have already mentioned the fact that mechanical irritations which induce long-continued regenerative growth processes may eventuate in cancer.

Many years ago Yamagiwa and Ishikawa discovered that the application of tar extending over relatively long periods of time may lead to cancerous transformations of the exposed rabbit skin. This malignant change passes through an apparently benign stage of wart formation. Subsequent investigations, especially by Kennaway and Cook, have shown that certain hydrocarbons related to substances found in tar are very effective in inducing the development of cancer. Carcinoma, and also sarcoma, may thus originate in a relatively short time and in a large percentage of the mice exposed to their influence. The most active of these substances are 1: 2: 5: 6-dibenzanthracene, 1:2-benzpyrene, and methylcholanthrene. At first it was thought that a specific chemical constitution could be associated with this cancerigenic action, but more recent studies have constantly added to the number of effective substances and it has been found that the latter may vary greatly in their chemical constitution. However, notwithstanding this relative lack of chemical specificity, it is noted that if we examine a single cancerigenic substance by itself, the nature and position of certain chemical groups determine its effectiveness. Furthermore, it has been shown that while in general all the tissues capable of growth on which these substances act may assume malignant growth, some of these compounds exhibit a certain selectiveness for definite organs; this selectiveness depends presumably upon the place where such a substance is retained for a sufficient length of time, especially during the process of its excretion.

In all the examples of experimental, and also of spontaneous cancer which we have mentioned so far, a definite stimulus could be discovered which was essential for the development of the tumor. In some cases it can be made very probable that even a combination of stimuli is responsible for this transformation of normal into cancerous tissue. Thus in the case of the experimental carcinoma-like changes of the vagina, portio and cervix of the mouse it can be shown that, in addition to the action of oestrogenic hormone, a mechanical injury to the surface epithelium due to friction exerts a stimulation on the epithelium, which very likely favors the initiation of cancerous growth. The same holds good presumably also in other cases. The localized effect of these mechanical factors would explain why, notwithstanding the fact that the hormone acts on the whole mucous membrane, carcinoma as a rule develops only in certain restricted areas. However while, as stated, the place of carcinoma formation is more or less localized and not general, nevertheless in vagina and cervix, as well as in mammary gland, it can be demonstrated that a malignant tumor does not start from a single transformed cell, as is still assumed by a number of investigators, but from larger structures such as ducts and acini, or certain areas of the surface epithelium. But gradually with continuing and increasing stimulation the growth

of these experimental cancers may extend to wider and wider areas and larger numbers of cancerous foci develop, until in the end the time can be foreseen when the cancerous change will become generalized. Observations such as these make it very improbable that the growth of malignant tumors depends upon gene mutations in somatic cells, to which it has been and still is referred by a number of pathologists. It is not very well conceivable that such mutations would occur simultaneously, or almost simultaneously, in so large a number of cells.

We have discussed so far the significance of stimuli in the origin of cancer. Such stimuli can be discovered in experimental cancers and they can also be shown to exist, or can at least be suspected in the large majority of spontaneous cancers in man, especially those developing in adults. However, there are other kinds of cancers in which it is not possible to detect such a stimulus which could be held responsible for their formation. This applies especially to those cancers whose origin can be traced back to embryonal stages. We must assume that in such cases constitutional factors, which are often or perhaps always hereditary, induce certain abnormalities in the embryonal development of a given tissue or organ; unknown stimuli, perhaps substances produced in the ordinary metabolism, may then transform as plastic a material as embryonal cells, endowed with a strong growth tendency, into cancerous tissues. Mixed tumors of the kidney, glioma of the eye, may be cited as examples of such cancers in which apparently constitutional-hereditary factors greatly preponderate over growth stimuli.

If we extend the definition of such constitutional-hereditary factors still further, so that they include not only family and individual but also strain and species constitutions, they can be shown to play an important rôle in all kinds of cancers. Thus carcinoma of the mammary gland is very common among many families of mice, but it occurs hardly at all in guinea pigs. If, on the other hand, we consider only families or individuals in a given species, heredity plays a very unequal rôle in different types of cancer. It has great significance in carcinoma of the breast of mice; it is much less significant and different in nature in cancer of the cervix and vagina of mice, if it exists here at all. As we have already mentioned, it is very important in the origin of certain embryonal cancers in the human species. In those types of cancer in which a hereditary tendency to the development of cancer plays a rôle, a deficiency in hereditary tendency in an individual, family or strain means that the amount of stimulation which it is necessary to apply in order to produce cancer is greater than in an individual, family or strain in which this tendency is great. An inverse quantitative relationship exists approximately between the degree of hereditary predisposition and the amount of stimulation that is required in order to induce cancer. As far as we know, this hereditary predisposition applies in each instance to a specific organ or tissue, and not, as a rule, to all the organs and tissues of the individual uniformly.

As to the nature of this hereditary predisposition, in some cases it may consist in a tendency to a certain malformation, in other cases in the degree of sensitiveness and readiness to respond to stimuli; in still other cases the hereditary tendency to acquire a certain disease which causes injury and subsequently regenerative processes in some organs may secondarily cause the predisposition to the development of cancer. In other instances perhaps the transmission of an agent may be involved in it. As mentioned above, there may also be differences in the mode of inheritance in different kinds of cancer; in some it may be by way of certain genes, in others by

way of the cytoplasm of the egg. This applies to tumors which may arise in different places in the same individual, as, for instance, in mammary gland and vagina-cervix of a mouse. In the inheritance of mammary gland cancer of the mouse in which the constitution of the mother predominates over that of the father, this difference in the significance of the two parents seems to be due largely or entirely to a factor transmitted by the mother's milk to the suckling young. On the other hand, in leukemia of mice, which may be conceived of as a cancer of the leucocyte—forming organs, the hereditary constitution of the mother likewise preponderates over that of the father, but in this case this condition does not, according to MacDowell and Richter, depend upon the transmission of an agent by the mother's milk. Considering all these circumstances it does not seem promising to attempt an eradication of cancer, or even a marked diminution in its incidence, by influencing the gene-composition of human families by means of selective breeding. The avoidance of stimulations leading to cancerous transformation of normal tissues is probably a much more hopeful procedure.

We may conclude that although the disease as such, as a rule, is not due to a change in a gene or chromosome of a somatic cell, the hereditary condition which makes certain organs or tissues prone to become cancerous may be due to mutations in germ cells, and this may explain why, in some cases, two sisters to whom the same mutation has been transmitted may both be affected by the same rare kind of cancer. We have in such instances in all probability to deal with hereditary changes transmitted by the germ cells and affecting the hereditary predisposition to the development of cancer in certain tissues.

While the cancers developing on an embryonal basis appear often in early life, the ordinary tumors originating in adult tissues are seen usually in older individuals. This preference for older organisms is noted in human as well as in animal cancers. It is due to the fact that the older the individual is, the longer a particular cancerigenic stimulus has had a chance to act; but in addition it is probable that changes in the constitution of various tissues, which are characteristic of old age, are favorable to the development of abnormal proliferations. This applies, for instance, to the human skin. However, in animals as well as in man, typical cancers of non-embryonal tissues may be observed in rather young individuals; we must assume that in such cases a threshold quantity of stimulation, sufficient for the inherited constitution of a certain tissue, has had a chance to become effective.

All the factors leading to the development of cancer seem then, directly or indirectly, to stimulate growth processes; the tendency to squamous cell metaplasia in tissues normally lined with cylindrical epithelium which is so frequently observed in precancerous conditions, represents probably an early stage of growth stimulation, and such changes are also induced by cancerigenic hydrocarbons in some organs; this has recently been observed after a series of injections of 1:2-benzpyrene in the prostate of the rat by Moore and Melchionna.

We may then conceive of cancer as the end-result of an amount of stimulation of tissue growth exerted during a certain length of time and exceeding a definite threshold quantity still compatible with normal activity, this quantity depending upon the constitutionally and often hereditarily determined receptivity of these tissues to a given type of stimulation. It may be assumed that as the result of such constant growth processes or of certain changes associated with the latter, the normal tissue equilibrium becomes in the end irreversibly altered, perhaps owing

to the rhythmic new formation within the cells of a substance which induces cell multiplication and initiates definite metabolic changes, or to the formation of an increased quantity of such a substance. This new formation may be conceived of as due to a process comparable to autocatalysis.

This is one possible explanation of cancerous growth. However, there are certain experimental facts which introduced some complicating elements. Many years ago it was observed by Peyton Rous that, contrary to what takes place in mammalian cancers, where only transplantation of tumor cells into other animals of the same species or strain gives rise to new cancers, in certain avian sarcomas it is possible to separate from the tumor a material free of living cells, which on injection into another individual of the same or, as was found subsequently, under certain conditions even of foreign though related species, gives rise to a new tumor. This cell-free material is therefore the carrier of an agent which is able to induce normal cells with which it comes into contact to assume the character of sarcoma cells of a type similar to those from which the agent has been obtained. Of a similar nature to the agent of the Rous sarcomas in birds seems to be the virus which causes leukemia or leukosis in chickens. This conclusion is corroborated by the finding in recent years that the viruses causing these leukoses may also induce sarcoma formation in the chicken inoculated with such a particular virus. There are various distinct viruses which have these effects and the investigations of Furth and Breedis show that each virus has its specific tissue affinity and tends therefore to produce malignant transformation in a specific type of mesenchymatous cell. These agents or viruses can be propagated in tissue culture and a culture of a sarcoma cell may thus be the carrier of a virus which induces not only the development of a sarcoma but also of leukemia after injection of these cells into a fowl; conversely, a myeloblast multiplying in tissue culture may be the bearer of a virus which transmits to a chicken not only leukemia, but also a particular kind of sarcoma.

The significance of such viruses is, however, not limited to birds and to sarcoma formation. More recently Rous found in the case of a mammalian tissue that a virus may be concerned in the origin of carcinoma. In cotton-tail rabbits there occurs a papillomatous growth on the skin which, as Shope has shown, is caused by a virus. If such a virus-papilloma is made to develop in a domestic rabbit, it may assume the characteristics of a carcinoma. Furthermore, if injected into the veins of rabbits in which the skin has been irritated and induced to undergo growth processes by long-continued application of tar, this virus has a tendency to fix itself to the growing cells and to cause their transformation into cancerous cells. On the basis of these important investigations Rous suggested that the action of a virus may be a necessary condition in the origin of all kinds of cancerous growths, even in mammals.

In the kidney of leopard frogs Lucké has observed in recent years the occurrence of a peculiar kind of adeno-carcinoma, in the origin of which a virus may perhaps be concerned. Moreover, recent experiments to which we have already referred, seem to indicate that the milk of the mother may transfer to the suckling young an agent able to convert mammary gland tissue, previously stimulated by oestrogenic hormones over long periods of time, into carcinoma, even in strains which are hereditarily not predisposed to the formation of such tumors. In this connection we may also recall some experiments which date back more than thirty years, in which it was shown that contact with a mammary gland carcinoma may induce malignant growth in adjoining, formerly normal, connective

tissue or epithelial cells. These observations also could possibly be explained by the transfer of a virus from the cancerous to adjoining normal tissue.

We may then state that certain tumors are caused by viruses which act as growth stimulators. These stimuli differ from certain other stimuli not only in so far as they are due to substances present within the cells themselves, but also in that they can be readily transferred to other cells of the same kind, and especially to actively growing cells. Whether the cells functioning as carriers need the continued action of such intracellular growth stimulators for their cancerous proliferation, or whether, as is the case with other stimulating factors, they can be dispensed with after they have acted over a certain period of time, is not yet known; the latter alternative might hold, even if it should be definitely shown that the virus remains associated with the cancerous cells and exerts certain effects throughout the life of these cells. In this type of virus-cancer, hereditary constitutional factors also seem to play a rôle in addition to the stimulating factors. Thus, as mentioned above, the transformation of rabbit papilloma into carcinoma is apparently more readily accomplished in the domestic than in the cotton-tail rabbit. As to the nature of these viruses, some uncertainty remains. It is probable that neither the agent of the avian sarcomas nor the virus of the rabbit papilloma are living organisms in the ordinary meaning of this term; on the contrary, there are very strong indications that the latter, and perhaps also the former, are very complex protein substances. The manner in which they propagate in the cells has not been determined. In the case of the Rous sarcoma there is some evidence that these active substances are, at least in part, derived from the cells in which they functioned as growth stimuli.

There exists then, as far as we know at present, the possibility that these intracellular agents or viruses may not be so very different from the autocatalytically propagating intracellular growth stimuli which we have considered as perhaps representing the active factors in cancerous growth. While the number of cancers in which such an agent or virus can be separated from the tumor cells and become the initiators of new growths in tissues of the same kind is at present still very limited, as Rous has pointed out, it is conceivable that such agents or viruses may play a rôle in other types, and perhaps in all kinds of cancers, and the inability to separate these active substances from the cancer cells in the case of the large majority of all tumors may be due to secondary conditions. But even if this last mentioned interpretation should ultimately prove to be correct, all the other stimulating factors which have been shown to play a rôle in the origin of cancer would still retain their great significance undiminished; without their cooperation the agent or virus would not become active under natural conditions. We may for instance assume, on the basis of the experiments of Bittner, that even in the origin of mammary gland carcinoma of mice a virus or agent exists; but nevertheless, the older investigations remain valid. In these it was shown that after early removal of the action of ovarian hormones by means of ovariectomy the appearance of mammary gland cancer is prevented, and that a quantitative relation exists between the time during which these hormones are allowed to act and the number of individuals which are subsequently affected by cancer. Therefore, without the cooperation of hormones such an agent or virus would be impotent and unable to induce cancer formation. There are other observations which tend to confirm this conclusion. We would then have to assume that cancerous growth is due to the cooperation of various kinds of stimulating factors

and certain specific substances, acting as viruses and being perhaps related to the hypothetical autocatalytic growth promoters, the importance of which in the origin of cancer we suggested many years ago. Likewise the hereditary constitutional factors which we have mentioned as causes of cancer would retain their significance. However, as the matter stands at present, it must be conceded that there are some facts which seem to offer difficulties to the view that viruses play a rôle in all types of cancer, especially some of the findings relating to the action of hormones in the origin of certain cancers.

This short review of the principal data which concern the origin of cancer shows that some of the basic facts have been experimentally established. We are able by experimental means to induce certain cancers at will and also to prevent their appearance in a quantitatively graded manner. The conclusions based on these experimental investigations are in harmony with and confirmed by the clinical observations of human cancer. There still exist important questions which future investigators will have to answer, but on the whole, the uncertainties and problems that remain have narrowed down considerably. These unsolved problems in the origin of cancer can now be well defined, and, essentially, they turn around the two possible conceptions which we have discussed, namely, (1) the effect of irreversible metabolic changes taking place in cells and tissues under the influence of stimuli leading to intensive or long-continued growth processes acting in cooperation with hereditary constitutional factors, and (2) the effect of the interaction between these growth stimulating factors and viruses. Experimental methods seem now to be available for the further analysis of these alternatives.

This formulation of the problem seems to us to be in agreement with the principal facts established so far. Even if future findings should replace it by something more adequate, at least it enables us to arrange the data known at present in a convenient and consistent manner, and to bring order into an otherwise apparently unconnected array of facts. It does not pretend to satisfy requirements as far as the cancer problem in the wider sense is concerned, which latter is a part of the problems of tissue physiology in general.

GREAT ABILITIES: THEIR FREQUENCY, CAUSATION, DISCOVERY AND UTILIZATION[1]

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COMMON sense and psychology use freely a scaling of abilities from little to great or low to high. John, who can solve all the business problems that Richard can solve and many more besides, has, we say, more business ability or a higher degree of business ability than Richard. If A can do all the acts of skill as a carpenter that B can do and others that are harder to do, we say that A has more or higher ability as a carpenter. A typist who, working as well as she can, makes two mistakes per thousand opportunities has less ability than one who makes only one. A person whose product or service in any trade or profession satisfies very exacting tastes has more ability in that trade or profession than one who can satisfy only the less exacting.

It would be difficult to frame a rigorous definition of "great" or "high" as applied to abilities to solve problems, manage people, manipulate tools and materials, entertain the intelligent, entertain the dull, and all the other multifarious works of man. And it is not necessary, and probably not even advisable, to try to do so at present. But it is well to have in mind three notable varieties of such scaling. The first includes cases where the upper end of the scale denotes chiefly ability to do harder things; the second includes cases where the upper end of the scale denotes chiefly ability to do the same thing better, more exactly, more elegantly, more pleasingly, or otherwise in a more satisfactory manner; the third includes cases where the upper end denotes chiefly ability to do more things. The third is much less important than the others and is rarely dealt with by itself alone as a high ability. Our common-sense scales are usually mixtures or composites of these three, but relatively pure cases are those of high ability in (1) invention, (2) singing and (3) a certain lowly type of scholarship.

Common sense and all the social sciences freely assume the existence in men of qualities or traits or combinations thereof which are the causes of this, that and the other achievement. High musical ability is the ability to achieve so and so, to produce such and such a product, of harmony, pleasure in the listeners, etc. High entrepreneurial ability is the ability to hire materials, labor and tools and achieve a product that can be marketed at enough to pay the bills with a large surplus. But of what musical ability and entrepreneurial ability consist or how they are related to other abilities very little is known. Indeed, it would perhaps be preferable to replace such terms as executive ability, statesmanship, artistic ability, military genius, business ability and literary ability in each case by "the ability to produce so and so," until much more is known than now about their respective constitutions and affiliations. Something real and biological doubtless does correspond to each of these terms, but it may be different in different persons, and the trait in A which, along with other traits in him, gives him high military ability, may, along with other traits in B, make B a

[1] Based on an address before the American Academy of Arts and Sciences.

great captain of industry, or may, along with certain features of C, cause or permit C to be a great reformer.

Causation

The causation of specially high degrees of ability is, like everything else in human individual differences, the action of certain events or conditions upon the genes. If all fertilized ova were subjected to just the same series of events, the men who developed from these ova would still differ in their abilities to remember, think, sing, draw, jump, govern, make money or whatever else. If there were millions having as nearly the same genes as "identical" twins have, and if a hundred different trainings were applied to ten each of the thousand, the groups would differ more or less in such of their abilities as were sensitive to the trainings.

The causation of specially high degrees of ability differs in no fundamental respect from the causation of any stated degree of ability. The doctrine of the irrepressibility of genius by any environment, no matter how unfavorable (often attributed to Galton) is unsound, though very high inborn capacities do have a notable tendency to seek and find an environment that favors them and a training that heightens them. The potency of training may be very low, so that the most favorable versus the most unfavorable social conditions that a human organism could encounter in the United States to-day would make very little difference in the ability. It may be very high, so that an average status of the genes acted upon by the best possible series of events will produce a higher ability than the optimal status of the genes acted upon by the worst possible series of events. General intelligence and singing are cases where training is relatively weak as a cause of very high abilities. Ability in diagnosing diseases and ability in translating Indian languages are cases where it is relatively strong.

In many of the abilities which are called upon in our civilization to produce or serve, such as legal ability, medical ability, engineering ability, dramatic ability, executive ability or political ability, we have made arrangements whereby the training without which a person can hardly manifest very high ability is denied to those who have only mediocre or inferior genes in that respect. They can not get into medical schools or medical practice; they can not practice entertaining audiences; they can not, except rarely by nepotism, get training as executives or be elected to public office. So only the originally able receive the training and we can not tell how much or little the training could do for persons of low natural capacity. And in general, partly because we give training in relation to capacity and partly because individuals of high capacity seek and find opportunities for training, the two sorts of causation act together in close correlation.

A high capacity may fail to manifest itself in demonstrated ability, by lack of the adequate stimulus. Military ability may lie dormant if there are no wars. The ability to manage a great enterprise through a hierarchy of subordinates, each possessed of certain special abilities to a higher degree than that of the manager, could hardly show itself in a pastoral civilization.

In general, very high ability is due to (1) fairly favorable qualities in the genes plus (2) the favorable training which such genes select or create, plus (3) the favorable training which parents, friends and society in general provide. The first is primary and essential. Without it the second will be absent and the third will be largely unavailing. The three together, or sometimes the first and second without the third, raise the abil-

ity year by year to levels such that it can profit by more and more advanced training. If this is withheld at any level, the ability is kept from attaining still higher levels. So doubtless there were in Europe from 1600 to 1800 many thousand men who might have been as able rulers as Gustavus Adolphus or Frederick the Great, so far as the constitution of their genes is concerned. It is very desirable to provide adequate early training to persons of probably favorable inborn capacities, and to add to it in proportion as they profit from it. A point is soon reached in the case of high abilities for which there is an economic demand at which further training is provided almost automatically and the person is paid well to take it.

It is of some importance to know how much of the payments made for high abilities are in the nature of rent for the natural resources supplied by the genes and how much are to balance the time and money spent in acquiring mental capital by training. The latter is surely usually only a very small fraction of the total. Lawyers who receive $100,000 a year on the average from age forty to sixty-five, average less than a dozen years of training beyond the age of compulsory school attendance, and less than a score of hours a week of unpaid study from the end of this training to age forty. For the rest, such a one gets his training from work for which he is paid more and more liberally as his ability becomes known and increases. Estimating the cost of his training from 14 to 26 and his unpaid study from 26 to 40 very liberally, a single year's wages at 40 would pay for all.

In most business men of high ability the percentage chargeable to training is still less. Before the days of schools of business, such a one was paid for almost all his business training; and often the more valuable the experience was for him, the more he was paid for it. The man who received $100,000 as president, received, as vice-president, $40,000 and also the training which brought his ability status up to that demanded of a president.

What is indubitable in the case of high legal or managerial or financial ability is often equally true of doctors, engineers, artists, musicians, actors, literary men, orators, politicians, salesmen, speculators, confidence-men and burglars of great ability. They are often paid liberally for much of the training that is most valuable to them.

A word may be added, somewhat out of place, concerning the disutilities which men of very high abilities suffer by exercising their abilities and training to improve them when they could be playing golf, lying in bed, reading novels, dancing or enjoying wine, women and song. They are very small in comparison to the enjoyment which they get from their work. The ratio of satisfaction gained from exercise of the ability to satisfactions lost from lack of certain other enjoyments is in general higher the higher the ability. This is partly because of a fairly close correlation between ability and interest, and partly because the provision and exercise of a high ability bring self-approval, a sense of personal worth and social esteem.

Frequency

Common observation reveals that very high abilities are usually very rare. This holds good even when almost everybody has adequate early opportunities and when almost everybody who shows fairly high ability as a result of these early opportunities is eager to get more and is likely to be given more. Such is now the case, for example, with singing. The number of tenors as good as Caruso and Jean de Reszke will always be very small, unless some new discovery in the physi-

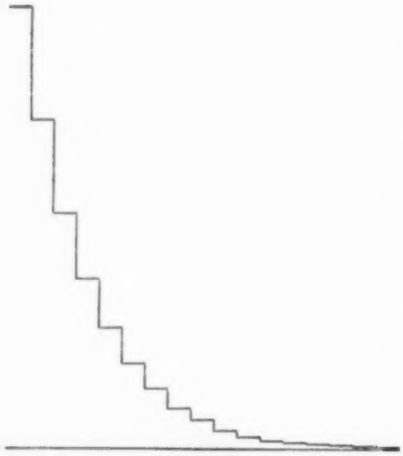


FIG. 1. THE DISTRIBUTION OF PERSONS OF VERY GREAT ABILITY (APPROXIMATELY THE TOP THOUSANDTH) IF VERY GREAT ABILITY IS CAUSED BY A FAIRLY LARGE NUMBER OF FORCES OF APPROXIMATELY EQUAL MAGNITUDE.

ology of the voice overcomes present limitations, or some new practice in human breeding multiplies these rare individuals.

By analogy with what is known of very high abilities that are definable and measurable, such as various athletic abilities, abstract intellect, knowledge of languages and ability to make money in a given profession, it is reasonable to expect that very high abilities are the extreme of a tail of a total surface of frequency, and that this tail has a form like that of Fig. 1, where the high abilities are due to specially favorable con-

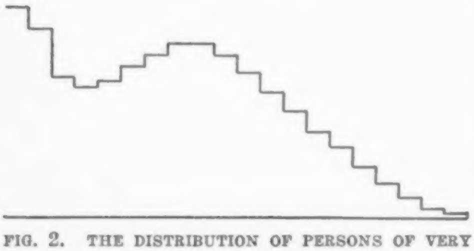


FIG. 2. THE DISTRIBUTION OF PERSONS OF VERY GREAT ABILITY WHEN THERE IS ADDED TO THE FORCES CAUSING THE DISTRIBUTION OF FIG. 1 ONE FORCE OF VERY LARGE MAGNITUDE.

catenations of many independent causes of about equal magnitude, or like those of Fig. 2 or Fig. 3, where the high abilities involve also the action of certain prepotent causes or groups of correlated causes.

Suppose the high levels of inborn capacity to achieve in a certain line (such as mathematics or law or banking) to be distributed so that the top 6,200 men out of a million will, if they receive no special opportunities, practice or training, be distributed as shown in Fig. 4 at age 50. Suppose that a certain cause or group of causes has the effect of raising the achievement in question from 5 to 16

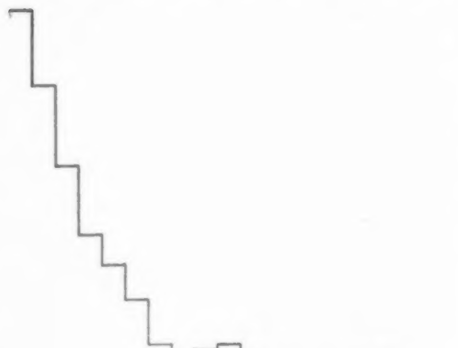


FIG. 3. THE DISTRIBUTION OF PERSONS OF VERY GREAT ABILITY WHEN THERE ARE ADDED TO THE FORCES CAUSING THE DISTRIBUTION OF FIG. 1 TWO FORCES OF FAIRLY LARGE MAGNITUDE.

points with an average effect of 10½. (Such a group might be going to a law school, and being admitted to a good firm.) Suppose that this cause or group of causes acts selectively, upon 10 per cent. of the men who would be at level 125 without it, upon 15 per cent. of the men who would be at level 126 without it, and 20, 25, 30, 35 and 40 per cent. in successive levels from 127 to 131, and thereafter accelerating its selective tendency so as to affect 46, 53, 61, 70 and 80 per cent. at successive levels. Then the distribution will be as in Fig. 5.

Suppose that a cause or group of causes acts in the same selective way, but now increases its potency in relation to inborn capacity from an average of $10\frac{1}{2}$ upon persons of the 125 level, to an average of $11\frac{1}{2}$ upon persons in the 126 level, to an average of $12\frac{1}{2}$ upon persons of the 127 level, and so on up to an average of $21\frac{1}{2}$ at the 136 level. Then the distribution will be as in Fig. 6.

It is often prudent to proceed upon some such assumptions in default of anything better, but so little is known concerning the nature and causation of such

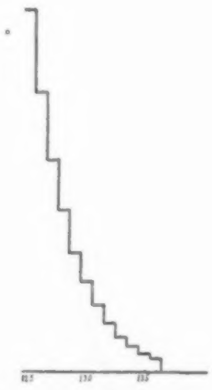


FIG. 4. THE PROBABLE DISTRIBUTION OF THE ABLEST 6,200 MEN IN A MILLION BY INBORN CAPACITY, THE AVERAGE OF THE MILLION BEING 100, AND THE STANDARD DEVIATION BEING 10.

abilities as to trade, manage men, direct a business, sell goods, organize a factory, select investments, foresee changes in fashion, conduct a trial, influence a jury, attract followers, and the like, that such assumptions in such cases are extremely hazardous. How many men in this country would be able to manage the American Federation of Labor as well as it has been managed? To design a dam demonstrably better than Boulder Dam was designed? To direct its construction demonstrably better than it has been directed? To secure 10,000 new subscribers for a certain magazine within

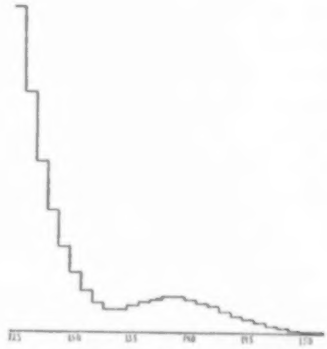


FIG. 5. THE DISTRIBUTION OF THE 6,200 MEN OF FIG. 4 IF THEY ARE SUBJECT TO A FORCE WHICH RAISES A PERSON'S SCORE FROM 5 TO 16 POINTS ($10\frac{1}{2}$ POINTS ON THE AVERAGE), AND ACTS UPON 10 PER CENT. OF PERSONS HAVING ABILITY 125, 15 PER CENT. HAVING ABILITY 126, 20 PER CENT. HAVING ABILITY 127, AND UPON 25, 30, 35, 40, 46, 53, 61, 70 AND 80 PER CENT., RESPECTIVELY, OF PERSONS HAVING ABILITIES 128, 129, 130, 131, 132, 133, 134, 135 AND 136.

a year? To displace the present national leader of the Democratic party within two years? To turn ten thousand dollars into ten million within ten years by

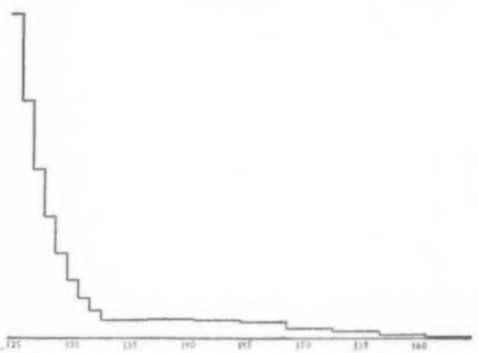


FIG. 6. THE DISTRIBUTION OF THE 6,200 MEN OF FIG. 4 IF THEY ARE SUBJECT TO A FORCE WHICH ACTS UPON 10 PER CENT. OF PERSONS HAVING ABILITY 125, RAISING THEM FROM 5 TO 16 POINTS; UPON 15 PER CENT. OF PERSONS HAVING ABILITY 125, RAISING THEM FROM 6 TO 17 POINTS; UPON 20 PER CENT. OF PERSONS HAVING ABILITY 127, RAISING THEM FROM 7 TO 18 POINTS; AND SO ON UP TO ACTION UPON 80 PER CENT. OF PERSONS HAVING ABILITY 136, RAISING THEM FROM 16 TO 27 POINTS.

trading, and increase this, or at least not lose any of it, during a second ten years? Experts in the various fields may dare to make estimates on the basis of their observations, but general observation and theory can not, as yet, do much more than to put the number somewhere between three and three thousand (or between one in ten thousand adults and one in ten million).[2]

Observation is likely to be misled by two opposite prejudices in estimating the rarity of men able to solve difficult science problems, manage great plants or firms, invest a million dollars a day wisely, or the like. If one thinks of the persons who are by common consent at the top level of ability and then moves down to estimate how many there are who are nearly as good, they seem very scarce. Close seconds to Carnegie or Caruso or Theodore Roosevelt in their respective generations do not readily come to mind. When Locke ran 220 yards in 20.6 seconds he doubtless seemed to many to have no close second.

Such abilities, found perhaps once in five hundred million men and admittedly peerless, are likely to make us belittle those who are really not far below them on the scale in question. In actual fact there were several available who could run 220 yards in only a second more, and there may be many business men and singers not far below the best.

If, on the other hand, one thinks of the symptoms and tests of an ability starting from the average and going to higher and higher levels, one may think that those at each level could, with a little better fortune or a little more effort, equal the achievement of a higher level. From running a small bank to running a large bank, from running one department of a department store to running the whole, from governor to president, the requirements do not seem to increase very greatly, and one may conclude that the next higher level of ability must have nearly as many representatives.

The Discovery of Specially High Abilities

Specially high abilities are presumably no more subject to chance or miracle than eclipses, the weather or anything else in nature. An omniscient observer could presumably predict how high ability any person would display in any line with any specified training. Our present powers of prediction seem slight in comparison with what can be done about eclipses or even about the weather, but are far above zero. A prediction much above chance can be made for any child even before he is born. From age 2 years 0 months or even earlier, certain abilities can be predicted from his sensory, motor and intellectual achievement to date. All predictions are, of course, in terms of probabilities and with a margin of doubt. As a person's development proceeds and records of his achievements accumulate, better and better predictions can be made. When, however, the ability to achieve a certain result, A, is inferred from anything save very similar achievement, there is a rather large probability of error. The specialization of some abilities is so great that abilities so similar as to be called by the same name may not be perfect indicators one of another. Also the person himself may change and so be able to do more or less than he could have done had he stayed the same. But this latter is probably the cause of much less error and doubt than has been supposed popularly. Great shifts like those of Grant are very rare.

Some abilities, as in abstract intellect,

[2] The six abilities taken as illustrations were not chosen with care to have them of even approximately equal height, but simply to be all fairly high, but not impossible of attainment. They probably differ much *inter se*.

music and mathematics, appear early; others, as in the management of men and of money, appear later. The guiding principle is that a capacity will show itself as an ability when situations are met which demand the ability and reward it. So a child with the capacity *can* show abstract intellect as soon as he knows a substantial number of facts and words, or musical ability as soon as he is acquainted with some system of relations of consonance, melody and harmony. If his activities are rewarded (perhaps only by his own enjoyment of them) he *will* show it. A person with the relevant capacity will similarly manage people and money as soon as he can profitably do so, but this will naturally be later. Cornelius Vanderbilt the elder was an active and successful entrepreneur at 12; but school laws, labor laws and social customs would probably prevent him from repeating this if he were born again.

Some sons of well-to-do parents seem to promise little until they graduate from college or professional school, having only a record of good sense, friendships and moderate success in games or other hobbies, and then manifest great ability in business or government. Some of the second-generation executives of Taussig and Jocelyn would doubtless illustrate this, as do the histories of the families which have so largely ruled England. The talents of these men are not such as to be stimulated by lessons or games, or rewarded by extra pocket-money or power over boys, but are called forth by the dignified responsibilities and rewards of adult life.

A scientific personnel manager for the world should, in his arrangements to utilize all specially high capacities, discover and keep track of: (1) children of parents of high achievement, (2) persons who are especially intelligent, (3) persons who are especially sensitive to beauty, (4) persons who are especially creative in the fine arts or useful arts, (5) persons who are especially desirous of excellence and persistent in striving for success, and (6) persons who are especially courageous and independent.

It is probable that a continuous account of the superior abilities that appear at ages 14, 18 and 22, with provision to keep careers open for their talents, would be a useful social investment. Even if nine out of ten of the recipients of such attention and aid achieve only moderately, the investment may yet be profitable provided one in a hundred of those near the top is enabled to do a higher quality of work than he would otherwise have done.

The full argument in support of this conclusion would be long and intricate, but its gist may be realized by considering what the world could afford to pay to develop the ability to cure cancer or make it fashionable for nations to settle their disputes by justice rather than force, ten years sooner than it would otherwise be developed. Even a slight rise in a very high ability is, roughly speaking, priceless. Even a small chance of such a rise is worth a large expenditure. We should not miss the chance by failure to discover the promising candidates early.

Business and industrial enterprises have been supposed to discover very high abilities surely and easily by work "on the job," but this has never been proved. Wise owners and managers of large enterprises are probably as eager to find such persons of high ability as these are to make their abilities known. But the conditions of modern mines, factories, wholesale houses, department stores, banks, railroads, etc., may prevent workers from knowing their own abilities and others from observing or inferring them. Consider the abilities of making financial decisions, improving processes, organizing production, organizing accounts,

managing inferiors, cooperating with equals, selling goods and trading in the case of a man 20 to 25 to-day. Except in the cases of selling and trading, there is some reason to believe that a man of high ability would have it recognized more quickly by becoming secretary, or even simply stenographer, to a high executive, than by working up in one of the regular divisions of the business.

The more the work of an organization is specialized and regularized so that each person's responsibilities are more fully described and prescribed, the less chance there is that persons can show their promise by extraordinary competence in emergencies. We may hope that impartial records of the quality of performance at the regular routine compensate for this lack. We may also hope that the displacement of a hundred thousand general manufacturers and business men by a hundred thousand engineers, accountants, shop-managers, superintendents, sales-managers, credit-men, legal advisers and other specialists not only permits a greater number of high abilities to work, but makes them more discoverable. Theoretically, it should do so. Theoretically, indeed, we should be able to discover high promise for many features of business and manufacturing in men while they are still students in schools of business and engineering.

There are no easy means of estimating how many fine flowers of managerial or entrepreneurial or financial ability waste their sweetness now, or have in times past. It would perhaps be worth while to measure the gains when some hindrance is removed, as when privates in the army are permitted to become commissioned officers by passing certain tests or by the exigencies of war, or as when customary restrictions of certain governmental posts to the nobility are abandoned.

Utilization

The best function of exceptionally high abilities is to perform valuable services which no lesser ability can perform at all, as in scientific discoveries, inventions, masterpieces of painting, music, literature and other fine arts, difficult problems and decisions, and difficult feats in inspiring, persuading, reconciling and otherwise managing individuals and groups.

In modern civilization there is always work of this sort to be done, so that very high abilities should never be unemployed, save for recreation. They should never do anything else, save as a luxury or medicine. From the moment that a man or woman has demonstrated his possession of such ability, society should, in its own interest, arrange that he does for it what only he and his kind can do.[3] If by a miracle some possible Newton or Dante could shovel as much sand per hour as ten thousand men, so that he could command four thousand dollars an hour as shoveler of sand all over the globe, society should, if possible, persuade him not to take that contract.[4]

If the n difficult jobs to be done can be distributed among the N men of high ability so that each does what nobody else even among them can do, or what he can do better than anybody else, there is an obvious arrangement for maximal utilization. But if some individual can do two or more better than anybody else, the matter is not quite so simple; and if the jobs vary in importance and some of the individuals surpass some of the others in

[3] These statements hold true even when there is not surety that he can do so and so, but only a certain probability higher than that for anybody else and enormously higher than the probabilities for 999 men out of a thousand.

[4] As the world is, the possible Newton or Dante would be wise to exercise his shovel magic for a few hours, so as to live thereafter free from financial worries!

several of them, it may be fairly complex. A solution giving maximal utilization will not then be reached if those in authority in respect of each job try to get for that job the individual who will do it best. But it can be reached if all jobs, importances, individuals and abilities are considered together. Table I shows the maximal utilization of ten men for twenty jobs of specified importance which none but they can do. For convenience, it is assumed that each job would require the same time as any of the others.

TABLE I

MAXIMAL UTILIZATION OF 10 PERSONS (A, B, C, D, ETC.) DOING ONE JOB EACH OF 20 JOBS. A y INDICATES THAT THE PERSON IN QUESTION CAN DO THE JOB IN QUESTION

Job	Importance	Person Assigned	Persons and Their Abilities									
			A	B	C	D	E	F	G	H	I	J
1	10			y	y		y		y	y		
2	10		y	y	y	y	y	y	y			y
3	11		y	y		y	y		y		y	y
4	12		y		y	y					y	
5	14			y			y					y
6	15		y		y	y			y		y	
7	15			y			y		y	y		y
8	16	I	y			y					y	y
9	16		y			y	y			y		
10	18				y			y	y			
11	18	C or F			y			y	y			
12	20	H	y			y		y		y		y
13	20	F or C			y			y	y			
14	20	G		y			y		y			y
15	20	D	y		y	y						
16	21	E		y			y					
17	22			y								
18	22	J	y				y					y
19	24	B		y								y
20	25	A	y									

The assignment or direction or attraction of high abilities to one job rather than another may be left to the individuals singly, or to a group of them, or to some body (such as the French Academy, the British Royal Society, the American Academy of Arts and Sciences or the American National Academy of Sciences) supposed to be competent to organize and direct the work of men of genius, or to some branch of the government, or to whatever universities, foundations or business concerns pay for their time.

Psychologically it seems safer to trust as a rule to the individuals themselves plus the guidance they will obtain in the ordinary course of events from their fellow experts. Great writers, painters, musicians, scientists, lawyers, reformers, business men and rulers will doubtless do some selfish, useless and silly things with their talents if paid to do what they please without let or hindrance. Cases can be cited where a great man did better under the pressure of a publisher's contracts, the need to compose music that the market would buy, a grant for the completion of a specified project, a popular demand, the dictates of a superior or other persuasion or coercion from those who were using his abilities, than when he used them freely. But on the whole what great men have done by choice will probably average much higher for the common good than what they have done by pressure from employers, advisers or the public.

Three facts need to be considered in this connection. The first is that there is a positive correlation of about .50 between intelligence and virtue or good will toward men. Consequently, unless we are competent in judging who will work in the interest of mankind, we will do better to trust our fortunes to able persons than to try to pick well-intentioned ones. Second, very able individuals are far likelier to judge correctly *what* work they are likely to succeed at and whether the time is ripe to attack it than anybody else, at least until some man of genius makes it his specialty to study what sorts of abilities are best adapted to what sorts of work. Third, very able persons usually attach much more interest and devotion to self-chosen work. For such a man to work at A when he yearns to work at B is especially wasteful.

Except for reasons of weight, then,

very high abilities may be permitted to choose their own jobs. There is still more reason to permit them to choose their own methods. Only for reasons of great weight should society or any of its agents presume to manage such men and women in their special lines of work.

But the correlations between special abilities and good will, good sense, cooperativeness, balance and other multipliers of a man's value, though almost certainly positive, are far from perfect. In the management of his general life the person of high special ability may profit greatly from direction, persuasion and even coercion *ab extra*. Wise publishers, producers, heads of educational or business institutions, financial and industrial managers, patrons and friends may protect them from distractions, irritations and follies and help to keep them healthy and happy.

The success of entrepreneurs in utilizing the labor of specialists of very high abilities will probably in the next hundred years be more important for their own profits and for the common good than their success in utilizing the rank and file of skilled and unskilled manual and clerical workers. The success of the public in making conditions such that high abilities work in its interest will also presumably become even more important than it has been. Less than ever can we afford to stone the prophets.

Public assistance may safely be given to the education of very able persons and their relief from labor which makes poor use of their abilities by allowances for maintenance. Present practices in the United States are often diametrically wrong, as where a gifted child who at a certain age has advanced far in school is permitted to be sent to work by his parents, while a dull child of the same age must be kept in school.

In the case of a random sampling of about a thousand boys in New York City whose careers were studied from 1922 to 1932, the number of years of schooling received by the top twentieth in intellectual achievement averaged less than half a year more than that for the bottom twentieth.[5]

The public should obviously on all counts demand systems of appointment and promotion by merit in all non-elective government services. This would open one set of careers to individuals of high abilities; and, if physicians, lawyers, workers in the physical, biological and social sciences, engineers and men of affairs who use high abilities for the public good are also given power and freedom in proportion to their demonstrated services, we should have a very useful, though incomplete, insurance against misuse and lack of use of these precious national resources.

The public should also take some pains to learn what sorts of persons and abilities are its real benefactors. It is not entirely fair to ask men of ability to act in the public interest rather than in their own, when the public chooses to be deceived pleasantly rather than told wholesome truths, to be poisoned rather than nourished, and to be debauched rather than ennobled.

Indirect provision for utilization of many sorts of high ability is made fairly efficiently by universities, hospitals, museums, foundations for the advancement of human welfare and other endowed institutions. These provide living expenses and facilities for work either as a gift or in return for moderate amounts of teaching or other service. Indirect

[5] It is a common error to think that society is doing more for the intellectually able than for the dull because the former reach much higher grades. This means chiefly that, with the same gift of schooling in years, the able achieve much more than the dull. In the sample referred to above the top twentieth reached grade 12, while the bottom twentieth reached only grade 8.

provision for utilizing many sorts more or less well is made by business concerns which employ not only men of great ability in managing men, money and machines, but also men of great ability as physicists, chemists, geologists, engineers, architects, economists, statisticians, psychologists, lawyers and others. Just how high the efficiency of the utilization is can not be stated. It probably ranges from a low point where the person is put at work which lower abilities could do as well, but where he at least has adequate livelihood with fairly congenial work, to a point where he is abundantly paid and provided with first-rate opportunities to exercise and improve his abilities. The latter is, of course, likelier to be the case with the abilities to manage men, money and machines, than with the abilities less intimately associated with the management of production and selling so as to meet some demand and thereby pay lenders their interest and shareholders some return on their investment. But the owners, if they interfere at all, will perhaps in the future interfere less with the specialists in a corporation's management than with the high general executives who plan its organization and appoint the top specialists. The high general executives have progressed far from the early days when they treated the specialists as distinctly subordinate in every way and always put upon them the burden of proof, and in general considered that they themselves know more about everything in the business than all those beneath them. They will progress still further and will give freer and freer play to the abilities of others so far as these are exercised for the good of the business. With the vexed question of the degree of correspondence between what is good for the business and what is good for mankind we are not here concerned, beyond noting that if the products produced or services rendered are themselves good for mankind and if there is the amount of control over matters of health, decency, justice and the like now prevalent in civilized countries, the correspondence is much above zero. We may not hope that Adam Smith's "invisible hand" holds it at or near 1.00, but no competent economist would rate it as zero or negative. Moreover, the features of the conduct of the business which are due to the activities of the very able individual specialists are, because of the correlation between ability and good will toward men, more likely than those of foremen, office-managers, salesmen and workers generally to be beneficial, in so far as the benevolence of able persons may be assumed to be beneficial.

There are certain sinister neglects and misuses of high abilities due to selfishness, nepotism, envy, jealousy and other base human passions, and others due to natural and normal self-esteem. A king may use his power fairly well in most respects, but, for fear of losing it, may make little or no use of the great abilities of some of his subordinates. The number of murders of near relatives by kings of old was very large! Dictators, even the most benevolent, seldom take much pains to train able successors. Men have resigned positions of great power and dignity in order to retire to monasteries, or by doctor's orders or to indulge in some hobby, but not often simply to give some abler man a chance to do their work better. Indeed, it is psychologically very hard for one to believe that some of his subordinates are abler than he is, since that conflicts with his long habit of dominance over them, and is also not a pleasant belief to entertain.

As a rule, a man's achievement rises till age forty, holds at a level until age fifty-four, and then falls, though not very rapidly, up to age seventy. But this is not widely known, and a ruler, artist, scientist, professional man or business

man who knew and believed it would still be strongly tempted to think that he was an exception. The drop being gradual and rather slow permits him to do this, and may conceal the fact from his associates until some dramatic comparison with a previous similar demand shows that he does not have the ablity he once had.

Very able men can not then be relied on to do full justice to other very able men in all circumstances. They are, however, more likely to do so than less able or mediocre men. The ablest kings will tolerate abler ministers than less able kings will; and we may expect that the ablest bank presidents will give way to promising juniors oftener and earlier than the petty magnates of small towns.

Very high abilities may be misused by their possessors because of two very important psychological fallacies. The first is the fallacy of overrating one's judgments of all or many sorts because in one's special field they are excellent. The second is the fallacy of assuming that one's might is right on all or many occasions because it has been right in one's special field. A man who day after day has judged correctly ninety-nine times out of a hundred about, say, legal problems, and who gains a moderate knowledge about sociology or politics or art, will feel an unjustifiable confidence in his judgments about the latter unless he reminds himself that he is disqualified from expertness in the latter. A man who has exercised power repeatedly with benefit to all concerned as, say, a bishop or general or company president, will feel an unjustifiable confidence in his exercise of power that comes to him as a college trustee or senator or director of an art museum, unless he deliberately allows for his lesser fitness for the latter parts.

Such misuses are not of very great importance, first, because men of very high abilities usually are too interested in their own specialties to interfere much in other lines; second, because they are intelligent about their limitations, and third because, even if overvalued, their exercise of thought and of power will still be much better than the average, though below that of the expert. Such misuses should, however, be reduced. In particular, men of very high literary or oratorical gifts could well have their statements about philosophy, religion, education, government and reform criticized by experts lest their talents make the worse appear the better; men of great ability to make money could wisely inform themselves concerning the correlations of this with other abilities; a man of high abilities of any sort should abate, outside of his specialty, the peremptoriness and absolutism which is his right within it.

If the leading specialist in treating a certain disease discovers a preventive of it, he may lessen his own income greatly by making the discovery public. Yet, as Professor Cattell has often remarked, the public gives him nothing to offset this. The ablest lawyers make a great financial sacrifice to take posts as judges or as professors in schools of law. Army officers highly competent in engineering and management have attractive chances to leave the service for private employment. And, in general, very high abilities which can be employed for private ends will be sought for these, and the private concern will usually outbid the public. For example, great scholars or scientists will be paid far more for writing text-books than for doing research. The case is different with low abilities, where the public often pays more money and security than private employers would offer.

The attitude of very able persons toward public versus private employment varies, of course, enormously with the person and the nature of the employment,

but certain facts are of wide applicability. Very able persons do consider, more than others, the common good and the good of the future and will make sacrifices for it. They seek, more than others, freedom to do excellent work and especially abominate either political or commercial pressure which forces them to do shoddy work. They demand permanence of tenure in public work not so much to be sure of a livelihood as to be sure of protection against political pressure. They are more sensitive than others and seek freedom to work in their own way and among congenial surroundings.

No community has planned and arranged to discover and utilize all the very high abilities of its members. There may be a large waste because of discouragement or lack of encouragement, especially lack of financial support. The amount of the latter varies from near zero in the case of some prophets, reformers, philosophers, mathematicians, scientists and scholars to a large superfluity in the case of some entertainers, managers, entrepreneurs and traders.

Since great ability has much more than its share of able ancestors, some provision is made by them. In Odin's study of the conditions of nature and nurture of eminent French men of letters, the number who were brought up in chateaux was large. In Taussig and Jocelyn's study of business executives, the parents were often successful business men. The sons of clergymen and teachers have been distinguished for high achievement in science, scholarship and the professions; and their parents probably usually provided encouragement other than financial.

Some provision is still made by individual patrons. Young people who are highly gifted in music or painting do receive such help and probably could oftener if they could not be provided for otherwise. A boy or girl equally promising in science or scholarship would probably not obtain such patronage and would now be regarded as eccentric and lacking in self-respect if he asked for it. After a certain amount of training the able protegée in art or music is left to earn his living and probably can do so without excessive sacrifice, though this is not sure in the case of musical composers.

In general, individual patronage is very rare, but the universities and foundations supply it in the form of scholarships and fellowships, a few of which are adequate for complete support. Maintenance allowances during the period of secondary education have been proposed in various places and are being seriously considered by public authorities in France. The provision of financial aid during training is very uneven and more benevolent than efficient. For example, the aid available for intending clergymen is far richer than that for intending physicians, the latter being indeed almost nil. The theory is rather to reward religious devotion and palliate future poverty than to provide for public welfare.

If he has somehow obtained training, the highly gifted engineer, lawyer, physician or clergyman can usually make a living at more or less instructive work. The highly gifted scientist or scholar can, if not too eccentric, make a living by teaching or expert service. Poets and other literary men can, thanks to Pultizer prizes and Guggenheim fellowships, receive financial rewards for the work they most wish to do, or can become entertainers, as so many of the greatest of their kind have done.

Prizes such as those of the Nobel fund have the merit of giving individuals of great ability wherewithal to provide essentials and make old age secure and also of informing the world who some of its great benefactors are. The same is true of a system of national pensions such as those of the British civil list, especially

if they are large enough to be impressive to the public. Such public honors by way of financial support are not popular, however, and even in the enormous increase of public expenditures of the last generation, almost nothing has been spent directly to reward great public services.

It therefore seems politic to work rather for the support of universities, museums, hospitals, social settlements, institutes for science and scholarship, orchestras, and the like which are for the public good in and of themselves, and which will provide, as one by-product, dignified and congenial ways of earning a living for those high abilities which are not paid for by the general demand for business and professional services.

Nobody knows how many of the very high possibilities in the genes of the ten million persons born in this country from 1870 on who survived to age 50 or later, have been realized. To be definite we may consider the fate of the top thousand in the ten million, that is, the top one per ten thousand. If some omniscient guardian angel could have recorded the possibilities of each of the ten million at conception, at birth, at age 5, at age 10, at age 15, at age 20, at age 25, at age 30, and so on, nobody knows how fully the possibilities existing for any thousand at any age were realized in their lives thereafter. But not the most ardent believer in the relative importance of the genes and their tendency to find or create the environment they need, would claim that the possibilities were 100 per cent. realized.

The reader may well make the best guess he can and act upon it when he has a chance as, voter, donor, adviser, or the like, to further the utilization of the nation's most precious asset. The writer's guess would be that our eventual utilization of possibilities existing at age 15 varies from as low as .30 in the case of capacity to govern well to as high as .80 in the case of managerial and entrepreneurial capacities, and to .90 or .95 for trading ability; is about .60 in the case of the fine arts, science and scholarship; and is about .70 in engineering, invention, law, medicine and education. These percentages concern the numbers of persons who are doing the sort of work which they should be doing in the world's interest. The percentages of utilization, including also putting their abilities to work as early as is best and keeping them at work under the best conditions, would be lower.

Probably nine out of ten psychologists and sociologists would consider my estimates as far too high.

COMMENTS ON CURRENT SCIENCE

By SCIENCE SERVICE[1]
WASHINGTON, D. C.

THE EFFECT OF SCIENCE UPON MAN

It can be argued that the only truly direct effect science has had upon man is the application of medical and health knowledge that has lengthened his life span and reduced the birth rate. Autos, radios and all the impacts of physical science upon man's environment? Merely indirect and secondary, although admittedly important.

An intellectually exciting idea put forth by Frederick Osborn, population authority, in some of his thinking on eugenics is this: "Both births and deaths are more subject to human decisions and to a man-made environment than ever in the past. Man is given a new responsibility he did not expect and which he is as yet wholly unprepared to discharge."

The objectives of the newer eugenics are not particularly radical and are not centered upon sterilization or such techniques. They are concerned with making the best of what we have through education. This applies to determining who shall be born into the world as well as what happens to them afterwards. Most emphatically eugenics to-day does not desire to make a selection between social, economic or racial groups.

In the last few years science has amply proved, in Mr. Osborn's opinion, that whether or not there are differences between such groups with respect to the average capacities of the individuals which compose the group, such differences in average capacity are relatively small. On the other hand, the differences between individuals in the same group are known to be very large.

Eugenics thus demands a selection between individuals. It asks simply for a gradual increase in births among those individuals who are above the average of their group in socially valuable qualities. It wants a gradual decrease in births among those below the average of their group in socially valuable qualities. On the average, it is found that those parents who provide the best home training for their children are also those with the best genetic stock. This is a rather happy philosophy for planning mankind's future.

PRODUCTION OF HEAVIER NITROGEN AND SULFUR ATOMS

When a factory starts to produce a new kind of product, that's news. When the product consists of a kind of matter that has never been available before, that should be even bigger news.

At Columbia University in New York City, Dr. Harold C. Urey is engaged in manufacturing for scientific purposes relatively pure isotopes, kinds of atoms that a few years ago science did not realize existed.

Dr. Urey is a winner of the Nobel prize in chemistry for his discovery of what is now called deuterium, the kind of hydrogen that is twice as heavy as the common kind. Deuterium (D) is now available in the form of heavy water and otherwise in extreme purity and in sufficient quantity. You can buy it for about a dollar a gram (1/30 of an ounce), which is cheap enough. Scientists use deuterium to tag the way compounds behave during chemical reaction. They are finding that the heavy kind of hydrogen

[1] Watson Davis, director, Frank Thone, Robert D. Potter, Jane Stafford, Emily C. Davis and Marjorie Van de Water, staff writers.

does modify the compounds in which it takes the place of common, light-weight hydrogen, although it is not deadly as some feared—or hoped—when it was first discovered.

Now Dr. Urey is separating out two other isotopes, nitrogen (N) of mass 15 and sulfur (S) of mass 34, which is a much more difficult task. He uses a sort of giant still that is 150 feet tall, or rather would be if a very trick, non-valve pump for gases and liquids did not allow him to put the whole apparatus on one floor. The heavier atoms of nitrogen 15 (the common nitrogen is mass 14) and of sulfur 34 (the common sulfur is mass 32) tend to separate out at the bottom. He is treating raw materials by the ton.

Just now there are only scientific uses, but you never can tell just when some industrial use will be found. Costs? Per gram-atom, D is $10 commercial; N 15 is $180 and S 34 is $40, for materials used.

POLARIZED LIGHT IN INDUSTRY

A new industrial revolution is in the making and it will be created out of light. Practical applications on a large scale are foreseen now that man can create and control the kind of light that vibrates in one plane only. This kind of light is called "polarized light."

What the vacuum tube, familiar in our radios, did for applied electricity, a cheap and convenient means of polarizing light promises to do for optics.

For many years the polarization of light has been understood and used in a limited way. Expensive Nicol prisms, made from suitable crystals of Iceland spar, have long been used in microscopes and other optical instruments. The effects of polarized light have long been demonstrated in classroom physics experiments.

It is startling to have light blotted out by a mere twist of a disc that had been perfectly transparent. This happens when the prisms are "crossed" or arranged so that their "one-way streets for polarized light" block each other.

The new development in polarized light is the commercial production of large sheets of polarizing material, called Polaroid. Millions of small, needle-shaped crystals of the chemical, sulfate of iodo-quinine, are laid down in a film, which may be a yard or more wide and continuous in length. This synthetic sheet polarizes perfectly. Some of the practical applications are:

A desk lamp that eliminates glare from papers on the desk.

Sunglasses that rub out sunlight reflections on pavements, sea, ice and snow.

Elimination of auto headlight glare by use of 45 degree polarizing screens on headlights and windshields of all cars.

Photographic filters for surface reflection elimination.

Colored illumination and advertising displays.

And the most promising of all, perhaps, stereoscopic or three-dimensional motion pictures in color.

THE STUDY OF VOLCANIC GASES

Professor Stanley S. Ballard, of the University of Hawaii, who is also research associate in geophysics in Hawaii National Park, tells in a new publication of methods for getting information about what goes on inside a volcano by capturing and studying the gases that come out of it.

The hottest parts of the volcano's breath, the gases that are actually flaming as they emerge, are of course uncapturable. Nevertheless, that does not mean that they can not be examined. By turning the slitted telescope of a spectrograph on them as they glow, it is possible to split their light up into its component wave-lengths and to get a record of these as lines on a photographic film for later measurement and interpretation.

Preliminary work of this kind has been done, but with instruments too small to

give really valuable results. Professor Ballard hopes to get a piece of scientific artillery of sufficient caliber to make a really telling assault upon the volcano's fiery citadel.

But actual samples of the gases themselves, that issue from fissures on the volcano's flanks and cracks in its crater floor, can be taken in suitable glass vessels, carried off to the laboratory, and put through the ordinary course of chemical analysis.

It is proverbial that "He who sups with the Devil must bring a long spoon." Volcanologists keep their distance by providing their sampling flasks with very long necks, and sometimes mounting them on poles as well. They poke the end of such a long-necked flask into the fuming volcanic vent. The flask has previously had its air pumped out; so when the seal is broken the gases rush into the vacuum. Then a stopcock is turned and they are trapped.

VITAMIN ALPHABET SHOWS SIGNS OF SHRINKING

From a vitamin expert and professor at Yale University School of Medicine, Dr. George R. Cowgill, comes the news that many claims for the existence of new vitamins have been shown to be untenable. What appeared to be new vitamins were just extra quantities of some of the old familiar ones.

Dr. Cowgill cited the case of the vitamin B complex as an example. Originally there was just one vitamin B, found in rice polishings, whole grains and cereals and yeast. Lack of this vitamin caused the severe nerve disorder, beriberi, in man and a similar condition, polyneuritis, in fowl.

After the original discovery, scientists continued to study this vitamin and the more they studied the longer grew the list of B vitamins. Finally there were vitamins B_1, B_2 (also called vitamin G by American scientists), B_3, B_4, B_5, B_6, and two more substances called filtrate factors. All of them were considered necessary for normal growth and each one was believed to have in addition certain special effects, or rather lack of each one was believed to result in separate nutritional disorders. It was all very confusing and a special committee of scientists had to be set up to straighten out the matter of names alone.

Now, however, things are growing simpler. The chemical structure of vitamin B_1 is known and the vitamin is called either thiamin, its chemical name, or simply vitamin B. It is the beriberi preventive. B_2 turns out to be riboflavin and instead of being a pellagra preventive is a preventive, Dr. Cowgill states, of a degeneration of the spinal cord. The special effects of B_3 and B_4 are now known to be due, according to Dr. Cowgill, to a larger supply of B_1. The effect of B_5, noted in pigeons, has been explained on other grounds.

THE FORMATION OF VENTILATION SPACES IN ROOTS

Cells dying that other cells may live furnish the explanation of the air spaces found in the roots of plants like water-lilies, cattails and other forms that grow in unaerated soil and yet must have oxygen to sustain life. Air from above passes down through these spaces, and carbon dioxide waste presumably goes out through the same channels.

But the death of cells in such root tissues is not a nobly self-sacrificing piece of altruism. They just can't help it. They happen to be the ones that suffocate first when the oxygen is cut off, and their breakdown leaves air passages open, so that the rest don't need to die. And thus the roots, and the whole plant, are enabled to survive.

The story of the formation of these ventilation shafts through living root tissues was told at the recent meeting of the Royal Society of Canada by Dr. D. C. McPherson, of the University of Toronto.

Dr. McPherson used in his experiments only plants that do not normally

need or have air passages through their roots, principally corn. When corn plants were grown with their roots deprived of oxygen, groups of cells died and degenerated, leaving spaces open, through which the remaining tissues obtained the necessary air. Parallel plantings with plenty of oxygen in the soil did not form air passages.

Some other plants, like peas and beans, proved unable to form air passages even though oxygen starvation killed cells in their roots. This was because a hard chemical compound, calcium pectate, formed in the cell walls, preventing them from breaking down when they died. Corn cell walls, made of softer stuff, can and do disintegrate.

Dr. McPherson considers that water-dwelling plants that normally have air spaces originally had none, but developed them in response to physiological need as they came to grow in unaerated soils. But now they are so accustomed to having these ventilation passages that if they are forcibly prevented from forming them they will die.

SCORPION STINGS AND SPIDER BITES

Scorpions and spiders come in for a drastic debunking at the hands of Professor W. J. Baerg, University of Arkansas entomologist. For all their dreadful reputation, there are no really deadly scorpions in the United States, and the only dangerously poisonous spider is the already notorious Black Widow. Scorpion stings, declared Professor Baerg, are no worse than those of wasps, and tarantula bites are about on a level with the jab of a dull pin.

Scorpions are ready to sting on slight provocation. The effect is immediately painful, but passes in about half an hour. Tarantulas are not quite so aggressive, though if you really want one to bite you she will usually do so upon sufficient provocation. But some tarantulas won't even do that. Professor Baerg mentions appreciatively a curly-haired Honduran tarantula that has never yet bitten him, despite all kinds of coaxing.

The Arkansas biologist is willing to venture one categorical statement with regard to tarantulas: "No tarantula has a poison that produces dangerous general symptoms in man. A few tarantulas are poisonous to man but the effect is local."

Outside the United States, and confined to Mexico so far as now known, there are a very few species of scorpion whose sting may result in death. One of them, ironically enough, prefers to live in the neighborhood of human habitations. Since the development in Mexico of a serum treatment for scorpion sting, the number of cases ending fatally has been much reduced.

Even the dreaded Black Widow, although admittedly able to cause extreme pain and violent discomfort, rarely kills, says Professor Baerg. "The patient always recovers (excepting possibly infants) unless hampered by serious complications such as a very weak heart, or a syphilitic condition."

Professor Baerg's conclusions are stated in detail in the June issue of *Natural History*, publication of the American Museum of Natural History.

THE TONE OF OLD VIOLINS

After two centuries, it now appears that scientific research is disclosing the secrets behind the tonal beauty which has rightly made famous the instruments of Stradivarius, Amati and other old Italian violin makers. Of more practical importance to all lovers of music, the researches of modern science are showing what must be done to make instruments comparable in tonal qualities with those of the old masters.

Although many men, including some of the best scientists in the world, have tackled this problem, it has been only recently that progress has been made. The ability to amplify sound waves electrically and to present a visual picture of the wave characteristics on an oscillo-

graph are the two key research wedges which are prying apart the long-lost secrets of an old violin's tones.

Once the wave form of a tone from a violin is obtained it is possible, by harmonic analysis, to discover the distribution of the sound energies among the fundamental tones and overtones. It is this distribution which sets off a Stradivarius from just another "fiddle."

Such overtones are caused by the multiple vibration of the bowed string. The existence of these extra vibrations can be shown by placing several little "saddles" of paper over the string and bowing it. Where the vibration is intense the saddles jump off. Where vibration nodes exist the saddles stay in place.

The Danish scientist Poul Jarnak, working in the United States through funds of the H. C. Oersteds Foundation, Copenhagen, has not only made studies on the tones of violins but has developed experimental instruments which compare very closely in tone with expensive 17th century Italian violins. This comparison is made not only by the oscillograph records but also by the ears of trained musicians, says Mr. Jarnak in a report published in the *Journal* of the Franklin Institute.

SUGARS IN NUTRITION AND INDUSTRY

All that is sugar is not sweet. Some sugars are bitter, others are poisonous. Besides the kind of sweet crystals in your sugar bowl, there are literally hundreds of substances chemists know as sugars. Some, like the common sugar, are cheap. Others are very expensive.

Nor is purity, in the case of sugars, a matter of cost. Sucrose obtained from the sugar cane or sugar beet is highly purified and it is one of the cheapest substances in the grocery store. An industrial bulletin from A. D. Little, Inc., points out that a crude sucrose, obtained from maple trees is relatively expensive and furnishes a classic example of how value may depend almost entirely upon the presence of impurities, which in this case impart the distinctive maple flavor that gives this sugar its favored place in commerce.

Dextrose and lactose are two other extensively used food sugars. Also known as glucose, dextrose is produced from the starch of corn and is sold as the major part (50 per cent.) of corn syrup and as dry white crystalline material. These crystals at about 4 cents per pound are perhaps the cheapest organic material produced. Lactose is milk sugar. Babies can digest it at birth. Heat caramelizes it to produce that attractive golden-brown color of biscuits, bread and pie crust.

Sugars are one of the important raw materials for chemical manufacture. Vast quantities of molasses are the starting point for producing alcohol, citric acid, yeast and other products. Dextrose is fermented on a large scale to produce chemicals and is reduced by electrolytic means to give rise to the sugar alcohols, mannitol and sorbitol, which are new to commerce.

One of the so-called rare sugars, trehalose or mycose, found in fungi and in the manna of Persia, is possibly the most chemically stable of all sugars, resisting the combined action of alkalies and oxidizing agents.

IMPORTANCE OF FATS IN DIET

Most persons do not need to be told to eat fat. They like the flavor and they have probably learned from experience that a meal with fat in it has more "staying" power than a meal without. So, more or less automatically, butter is spread on bread, oil is put in salad dressings, cream goes in coffee and bacon is eaten with eggs.

The scientific reasons for eating fat and some of the newer knowledge about fat are less well-known but interesting. For example, the reason why you feel hungry sooner after eating a meal with little fat than after a meal with lots of fat is because fat leaves the stomach more slowly

than protein foods or starches and sugars. Moreover, fat eaten with these other kinds of foods—bread and butter or bacon and eggs—retards the digestion of the other food substances.

Besides adding to the feeling of satisfaction after a meal, fat is the best of all foods for giving energy. Weight for weight, the fats give more energy than either proteins, such as meat, or carbohydrates, such as bread, cereal and potatoes. The reason for this is that fats contain a higher proportion of carbon and hydrogen, they are relatively drier than the carbohydrates and proteins as ordinarily eaten, and fats are more completely digestible than the other classes of foods so that there is almost no waste.

You can get along with very little fat. An experiment has been reported in which a man lived for six months on a diet containing only two grams of fat per day. Two grams is equivalent to about seven hundredths of an ounce—a mighty small speck of butter. Surprisingly, this man felt no fatigue. The rest of his diet, however, was very carefully planned. An ordinary fat-lacking diet, such as was eaten in European countries during the World War, results in premature hunger, lowered energy and reduced capacity to work.

The average adult should eat about one third of his daily calories as fat. Margarines or processed vegetable fats give better value for the money than butter, but ordinarily lack the vitamins A and D which butter supplies.

AUSTRALIAN TRIBES

America has its Indian problems. Australia is having trouble with its aborigines. Australians have not, of course, left the black men entirely to shift for themselves. They have studied the natives as interesting specimens. They have provided aboriginal reserves. They have offered medical treatment. Recently they appointed an anthropologist to be Protector of Aborigines.

But still Australia's tribes are reported to be "dying on their feet."

Somehow, these Stone Age people evade the scraps of civilization handed to them. They prefer to roam where they please. Sick as thousands are, they are wary of white doctors. They continue to die, rapidly.

Defenders of the natives protest against unfairness on some reservations, where white men encroach, taking land for their industries and their own uses.

Sir James Barrett, of Australia, in a letter to *Nature*, points out that there were about 300,000 aborigines in Australia when Europeans took charge in 1788. Now, there are none in Tasmania, about 50 in Victoria, a few in New South Wales. Tropical Australia still has about 60,000, and there are some 22,000 half-castes.

Sir James suggests that half-castes or aborigines be trained in medicine, so that they may give medical care to their own people.

Anthropologists have suggested that the natives be put on land where outsiders are admitted only on duty, and that the natives be left in peace to live in their own fashion.

The natives have a suggestion. Recently, they petitioned King George, asking representation in the Federal Parliament. This, they believe, would help them to get justice in the matter of lands and legal rights. They even believe it would save their people from extinction.

Representation seems to be one feature of civilization these natives have decided they need.

BIBLICAL PLAGUES AND EGYPT'S HEALTH

The Biblical plagues still afflict the land of Egypt. Far from being a never-repeated reign of terror, the plagues with which Moses frightened a Pharaoh into releasing the Israelites were fearful because of their familiarity. And they

still recur in more or less serious form, like our own epidemics and other trials.

The sequence of health hazards which the Nile brings each year was deplored recently before the World Federation of Education Associations by a physician of the government health service in Cairo, Dr. Isabel Garvice.

Pointing out the Biblical antiquity of these conditions, Dr. Garvice said that every August, then and now, the rising Nile turns blood-red from its load of heavy mud.

To drink this water is to invite sickness and death. Yet the Egyptian peasant is convinced that drinking well water would turn his hair gray and make him old before his time. Rather than risk such calamities, he clings to his year-round habit of drinking from river or canal, and the blood-red water brings the plague of boils. The children, says Dr. Garvice, often have ten to twenty boils on face and body.

As the flood waters lessen, come the plagues of frogs, flies, and death to the babies.

Even the three days of darkness which enveloped the earth in the Bible siege of plagues, is still experienced. The darkness takes the form of sandstorms, which are still terrible in upper Egypt and still last three days.

"All these things," said Dr. Garvice, "are put down to the will of God and accepted with resignation by the peasant."

But the Egyptian government is determined to cope with its plagues. Children, under compulsory schooling, are being taught health habits and given medical attention. Rural villages are shown hygiene films. Medical centers are established. The conquest of the plagues is advancing—slowly.

INSECT PESTS IN JUNE

If we mortals really could control the weather, as sometimes we wish we could, we would be up against a very difficult problem in June. What this country needs is two kinds of June: a cool wet month, with driving rains, from Illinois west to central Kansas, and a hot, dry one from Indiana east to New England.

This is because of the crop pest situation. In the corn belt the great threats are grasshoppers and chinch bugs. These thrive in hot, dry weather but are drowned, beaten into the earth, and exposed to their natural enemies by cold rains in late spring.

From Michigan and central Indiana eastward, the outstanding enemy is the European corn borer. The flying adults move from field to field most easily in cool, moist weather, so that farmers in its occupied territory have cause to pray for less rain rather than more. A really good dry spell some time in June would prevent a good deal of the damage that otherwise will befall corn and the many other crops the borer infests.

There is a certain amount of overlap in the ranges of chinch bugs and corn borers, so that in that area there is bound to be some trouble, no matter what the weather.

Probably, if a choice had to be made, it would be better to take the weather that would discourage the borer, and to tell grasshopper and chinch bug to come on, and to come a-fightin'. For entomologists have worked out control methods for the two latter pests which are fairly effective, even if expensive, while for the borer no real control has yet been discovered.

The best that can be done to fight corn borer is to make a thorough cleanup of all stubble in the fields it infests, plowing it under clean and deep and burning what can't be plowed under. The resting larvae lurk in such trash, and if any of it is left undestroyed, presently there will be enough of the winged adults to reinfest the whole neighborhood.

TREES THAT UNITE WITH EACH OTHER

By Dr. HENRY I. BALDWIN
NEW HAMPSHIRE FORESTRY AND RECREATION DEPARTMENT

TREES are naturally gregarious plants, but they are usually distinct individuals like animals. Occasionally some groups like mangroves in the tropical coastal swamps, and our speckled alders (not usually classed as a tree) grow from a common root and are hopelessly intermingled. Yet even in sprout forests, stems which branch below breast height are commonly considered separate trees. Many stems springing from a common root or base is a common form throughout the plant world. Single stems or branches which later unite are, however, unusual and deserve mention.

Natural grafting, as this odd joining of stems or branches is called, by analogy with the artificial horticultural practice of grafting twigs or scions of one variety on stock of another, is more common in some regions, and among some species than others. It is also much more common underground between roots than above ground. Tropical trees, shrubs and vines are especially prone to join their members. The late Dr. John K. Small has described grafts in the pond cypress (*Taxodium ascendens*) and in several sub-tropical hardwoods.[1] The tropical strangling fig forms unions with the slightest contact.

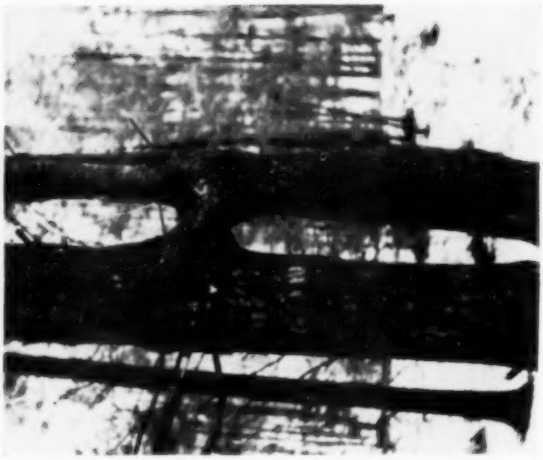
In temperate regions trees with very active cambium or growing layers close under the bark tend to graft more readily than other kinds. Spruce, for instance, almost never joins, but hemlock does often. Aggressive species graft more commonly. In second growth forests in the Northeast white pine, the maples, birches, ash, basswood and beech not infrequently become fastened together and occasionally the wood fibers become joined and the sap stream passes from one member to another. Where the bark is occluded and the branches or trunks are merely stuck together there is really no union. These may be termed false grafts. In no case observed by the writer has an actual union of the living wood elements occurred between different species of trees, but it may take place. "False grafts" are especially common in second growth hardwoods where sprouts crowd one another for space.

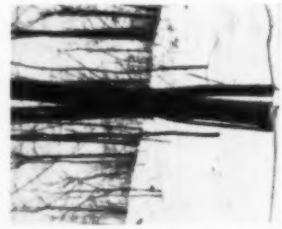
Stem grafts only are illustrated here, but root grafts are almost omnipresent. The competition for growing space above ground in the forest is as nothing compared to the maze of roots beneath. The soil is a far more unyielding medium than air, and when roots become interlaced and then grow in diameter there is frequently no room for expansion except into one another. Arborists speak of root-girdling. LaRue[2] examined stump fences in Michigan and estimated that at least 3,000 white pine stumps in a distance of 10 miles showed root grafts. Some individual stumps showed as many as 120 separate grafts. The writer has made similar observations in northern New York and New England. Hemlock also forms root grafts and where beech roots are exposed they will be found cemented together into a regular network. This condition was demonstrated strikingly during some tree injection experiments carried on by the writer in

[1] J. K. Small, *Jour. N. Y. Bot. Garden*, 33: 213–219, 1932.

[2] C. D. LaRue, *Am. Jour. Bot.*, 21: 121–126, 1934.

UPPER LEFT. DOUBLE GRAFT BETWEEN TWO PINE STEMS, FOX RESEARCH FOREST, HILLSBORO, N. H. UPPER RIGHT. GRAFT BETWEEN TWO PINES, FOX RESEARCH FOREST, HILLSBORO, N. H. THE DEAD TOP OF THE GRAFTED PINE PERSISTS. LOWER LEFT. TRUE GRAFT BETWEEN TWO YELLOW BIRCHES, WITH FALSE GRAFT ON SUGAR MAPLE. MT. SUNAPEE, N. H. LOWER RIGHT. GRAFT IN WHITE ASH. CONTOOCOOK STATE FOREST, HOPKINTON, N. H.





LEFT. YELLOW BIRCH AND WHITE PINE GROWING IN INTIMATE CONTACT ON HARVARD FOREST. A FALSE GRAFT. TREES CUT FALL 1934. PETERSHAM, MASS. UPPER RIGHT. TRUE GRAFT BETWEEN TWO WHITE PINE STEMS. FOX RESEARCH FOREST, HILLSBORO, N. H. BELOW LEFT. TRUE GRAFT IN BEECH. EDGEWOOD PARK. WHALLEY AVE., NEW HAVEN, CONN. BELOW RIGHT. GRAFT IN BLACK BIRCH. MALTBY DIV. ELI WHITNEY FOREST, NEW HAVEN, CONN.

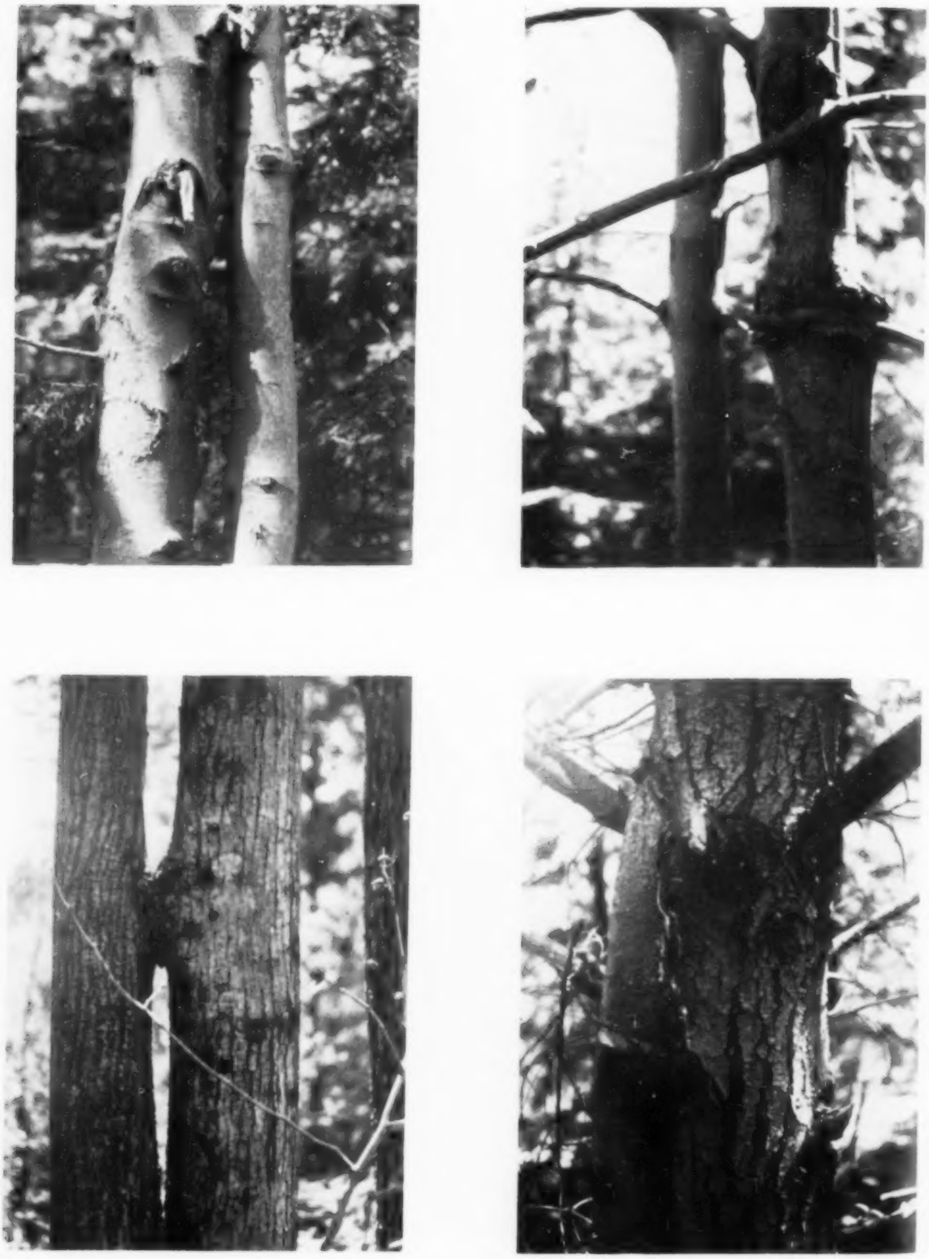
1925. When a red dye was introduced into one beech all others for a radius of 50 feet were found to be dyed. A similar experience is reported in dutch elm disease control work. Infection in one tree in Indianapolis was found to have spread to six others with whose vascular system it was joined by root grafts. Callousing and continued growth of stumps after the trees have been cut is another common evidence of root-grafting. Page[3] has studied these in white pine near Hanover, N. H., and found that stumps continued to grow for several years following cutting from food supplied by nearby trees. Büsgen and Münch[4] also report root grafts in spruce, silver fir, douglas fir, larch and rarely in scotch pine, causing stumps to live for decades. LaRue failed to find root grafts in tamarack (American larch). The forester can not always eliminate competition below ground by thinning the aerial parts of trees, it would appear.

[3] F. S. Page, *Jour. Forestry*, 25: 687–690, 1927.

[4] M. Büsgen and E. Münch, "Structure and Life of Forest Trees." English translation by Thomson. 365. N. Y., 1931.

A good illustration is furnished by girdling experiments. In 1924 hardwoods in Northwestern Maine were girdled in order to release spruce suppressed by them. Some trees died the first year, others in 3 or 4 years, but some small beeches were only slightly impaired in vigor by this ringing and were alive 10 years later. Now beeches are extremely sensitive to changes in moisture supply, and hence easy to kill by ringing. Examination showed numerous small saplings which were either root suckers or were grafted to the roots of the girdled trees. The nature of the cambium probably determines what species form root grafts. LaRue concluded that abrasion or friction of the bark due to rocking of the trees was not necessary to cause the cambium layers to unite, but that the pres-

LEFT. BASSWOOD TREES IN CLOSE CONTACT. A SITUATION WHICH SOMETIMES GIVES RISE TO GRAFTS. RIGHT. TRUE GRAFT BETWEEN PINE STEMS.



UPPER LEFT. FALSE GRAFT BETWEEN TWO RED MAPLES. FRICTION AT A BRANCH CALLOUS. THIS MAY LATER BECOME A TRUE GRAFT. UPPER RIGHT. FALSE BRANCH GRAFTS IN RED MAPLE. LOWER LEFT. CALLOUS IN BASSWOOD. MAY LATER BECOME A TRUE GRAFT. LOWER RIGHT. SMALL PINE GROWN INTO LARGER ONE.

sure of the soil and centrifugal growth kept the roots pressed firmly together and was sufficient.

Abrasion of trunks swaying in the wind has also been held responsible for grafting of stems. It seems undoubtedly to have been a factor in "false grafts," as well as true unions in New England second growth. Other influences are pressure of growth and adhesives, such as resins, gums and pitch which exude from abraded surfaces, taking the place of the orchardist's grafting wax. The original cause of many grafts has been the phototropic bending, storm damage, nibbling of cattle or weeviling which distorted the stems and branches and brought them into contact. There would appear to be a much higher frequency of grafts in pastured woodlands than in ungrazed areas. Branch stubs and swellings on the trunk often serve as initial points of contact. As the bark is scraped and bruised a callous develops and growth forms a larger and larger protuberance in healing the scar; this in turn aggravates the friction and eventually a true graft may result from the sticking together of the two callouses.

The upward bending of a lateral branch by correlation, following loss of the leading shoot by weevil injury may account for some of the grafts observed in white pine. Trees 8 to 10 inches in diameter growing a few feet apart are found joined 8 to 20 feet above ground, one trunk curving and disappearing into the other. In one case there are two such connections at a distance apart representing that of a branch whorl. A dead stub at the top, in continuation with the bole suggests the weeviled tip of the original independent tree. Clumps of pines growing in pastures frequently become intergrown.

Sections through true grafts show complete union of conductive tissue so that the start of the connection is obscured. Grafting in trees, unlike that in human polities, is of negligible commercial importance, since timber in which it occurs is of relatively low value.

OTTAWA FROM THE AIR

THE PROGRESS OF SCIENCE

AMERICAN AND CANADIAN SCIENTISTS MEET IN OTTAWA

From June 27 to July 2 the American Association for the Advancement of Science will hold its first meeting in Ottawa, Canada. On four previous occasions the association met in Canada: in Montreal in 1857 and 1882, and in Toronto in 1899 and in 1921.

The Ottawa meeting will combine to an exceptional degree the advantages of a great gathering of scientists and an excursion into a region noted for its attractive scenery. Fortunately Ottawa is not in some distant part of our continent but within easy reach of the populous parts of the United States extending from New England to the Mississippi River and as far south of the Potomac and the Ohio rivers. It may be reached by through trains from the principal American cities or by automobiles over excellent roads.

Perhaps the greatest emphasis in the extensive and varied program centers in the second of the "Science and Society" conferences which will be presented under the general title "Science and the Future." The four sessions of these conferences have been assigned the character of General Sessions at hours almost completely free of competing attractions. Scientists have become acutely aware of the fact that the results of their investigations are having profound indirect, as well as direct, effects upon society, and they are beginning to accept a responsibility for examining into these consequences of their work. This broadening of the interests and feeling of responsibility of scientists is by no means limited to the association. It is perhaps even more acutely felt in European countries, particularly in England. At the present time discussions are very active in *Nature* on the question of establishing an organization for investigating the effects of the impact of science on society.

It would be unfair to other parts of the program at Ottawa to stress unduly the Science and Society conferences. It may be mentioned, however, that these conferences will be participated in by two Nobel prize winners and the president of the National Academy of Sciences, as well as by other eminent scientists from both sides of the Canadian border.

Broad symposia, often ranging freely across the usual boundaries that separate the sciences, are becoming more and more distinguishing features of the association. This evolution in the character of its progress is natural both because of the progressive subdivision and specialization of science and because the association through its fifteen sections and its 165 affiliated and associated societies covers essentially all of science. Its steadily increasing active membership now exceeds 19,000.

Among the symposia worthy of special emphasis is the one on "The Use of Isotopes in Biological Chemistry," which will naturally be participated in by physicists, chemists and physiologists. The fact that the isotopes of the elements are distinguishable from one another while retaining their chemical properties, places in the hands of scientists a new and extremely important means of following the physiological processes.

Another symposium in a related field is on "Micro-elements and Deficiency Diseases." One having more easily comprehended practical aspects is on "Nutrition Problem in North America." Perhaps this is related to the symposium on "Drought Resistance." In the field of medicine there is a symposium on "Medical Biochemistry" which will be participated in by Dr. Banting and other distinguished scientists who have reduced the world's woes by the discovery of the rôle of insulin in metabolism and methods of its isolation and purification. A different factor will play an important

PEACE TOWER OF THE PARLIAMENT BUILDINGS FROM EAST GATE

part in the symposium on "The Influence of Fire on Forests, Wild Life and Public Welfare." Of equal importance to biologists as well as bacteriologists and veterinarians is the symposium on "The Genetics of Pathogenic Organisms in Relation to Human Welfare." Another symposium of interest to biologists and conservationists is the symposium on "The Migration of Salmon—and Conservation."

Not every discussion at the Ottawa meeting will be on living things, at least directly, for there will be a symposium on "Atmospheric Ozone and Measurement of the Ultra-violet in Solar Radiation." Perhaps I should not state positively that this subject is not directly related to life, for it is quite within the bounds of possibility that ultra-violet radiations may be found to have very important direct and indirect effects upon living organisms.

The ability of British and Canadian

scientists to provide enjoyable excursions and social diversions that give a lighter touch to their meetings is well known. The arrangements at Ottawa made by the Canadian Committee promise to measure up to the high standards for such things that have become a tradition with them. Those from this side of the border will enjoy them and it is hoped will learn of their advantages in relieving from time to time the more serious nature of the programs of the association.

F. R. MOULTON,
Permanent Secretary

MEDALLISTS OF THE NATIONAL ACADEMY OF SCIENCES

AT its seventy-fifth annual meeting on April 25 to 27, 1938, in Washington, the National Academy of Sciences awarded medals to two scientists who have made noteworthy contributions to science. The medals were presented at the annual dinner by the president, who, in accord with established custom, spoke first on the status of the academy, on its recent activities in furthering progress in science and on the aid given the federal government in problems on which advice has been requested.

These addresses by the president reflect the more important trends in current science and record, in a general way, the service rendered to the government by the academy. They are important statements, clearly written and authoritative. In his address President Lillie commented briefly upon the fiftieth anniversary celebration of the academy a quarter of a century ago and referred to some of the events since that time, including the world war, and to the services of the academy as scientific adviser of the government during that period. He alluded to the establishment and increasing importance of the National Research Council; to the steady growth of "consciousness of social and political responsibility that attaches to scientific leadership in our times"; and to the increasing realization of the importance of our foreign relations. In keeping with this realization the Royal Society of London and the National Academy of Sciences have recently proposed the Pilgrim Trust Lectureship. To quote Dr. Lillie:

Under the terms of this relationship it is agreed, on the invitation of the Royal Society, that the Pilgrim Trust Lecturer shall be appointed annually; in alternate years an American scientific man to be appointed by the Royal Society to give the lecture in London, and a representative of British scientific men to be appointed to give the lecture in Washington. This arrangement is supported by a grant of 250 guineas per year for a period of six years by the Pilgrim Trust. I am happy to announce that the Royal Society has appointed as the first Pilgrim Trust lecturer our fellow member Dr. Irving Langmuir, to speak in London in December of this year.

This very welcome consummation has also been the occasion of renewal of pledges of mutual hospitality to our respective members in London and in Washington. The President of the Royal Society alluded most cordially to this arrangement in his anniversary address last November. We join with him in the wish and expectation that science, which stands apart from all nationalism, may become an increasingly strong bond between the nations of the earth.

At the close of the president's address the medals are presented. The president calls upon the chairman or other member of the Trust Fund committee, recommending the award, to state briefly the reasons for the selection of the medalist, who in turn expresses appreciation of the honor bestowed upon him. The ceremony reflects much of human interest and affords opportunity for public expression of the value of the work of the medalist to science.

THE AGASSIZ MEDAL FOR OCEANOGRAPHY

The Agassiz Medal was awarded to Dr. Edgar Johnson Allen, director emeritus of the Plymouth Laboratory of the Marine Biological Association of the United Kingdom, Plymouth, England, "in recognition of his personal researches on marine biology and the great influence which he has exerted on the study of

DR. E. J. ALLEN

marine organisms in the relation to the marine environment."

Dr. E. G. Conklin, a member of the Murray Fund committee, which recommended the award, stated in his presentation speech that

Dr. Allen has been in a very real sense the creator of this laboratory, which is one of the most important in the world. A British colleague has written that "it was universally regarded as a white elephant when Dr. Allen took the directorship and turned it into a highly efficient research institution." In 1902 the Plymouth Laboratory was placed in charge of the British work on the International Commission for the Exploration of the Sea with Dr. Allen in charge of investigations. These investigations have been carried on there ever since and include studies on hydrography, meteorology, currents, plankton and other marine organisms. By means of these studies the circulation of oceanic waters in the English Channel and North Sea have been charted, and the movements of swarms of plankton and their relation to food fishes have been determined.

For his contributions to oceanography in the creation and wise direction of the Plymouth Laboratory; for his unselfish cooperation with hundreds of investigators at the laboratory for the past forty-two years; for his active work in connection with the International Commission for the Exploration of the Sea; for his direct contributions to the study of the life of the sea and its relation to human welfare, the committee

DR. W. R. WHITNEY

on the Agassiz Medal takes particular pleasure in recommending for the award at this meeting a friend of Sir John Murray and Alexander Agassiz—Dr. Edgar Johnson Allen.

Dr. Allen was unfortunately not able to receive the medal in person, and Leander McCormick-Goodhart, Esq., of the British Embassy, accepted it gratefully for transmission to Dr. Allen through diplomatic channels.

The Public Welfare Medal

The Public Welfare Medal from the Marcellus Hartley Fund was awarded to Willis Rodney Whitney, of the General Electric Company Research Laboratories, Schenectady, New York, "in recognition of his outstanding work in the fundamentals of scientific research for the public good."

Dr. A. W. Hull, chairman of the committee that proposed the award, in his presentation address referred briefly to Dr. Whitney's

outstanding contributions to human welfare in the field of electric lighting, and in the use of high-frequency electric currents for curing diseases such as paresis, arthritis and bursitis.

His greatest contribution, however, is as organizer and director of scientific research. Not the common organizer. The very term does him injustice. His organization was a growth rather than a creation. It grew so gradually that it is

difficult to give any date when it became an organization, except the date, November, 1900, when the M.I.T. professor began sharing his time with General Electric, spending two days each week in Schenectady.

The laboratory that has grown up under his leadership is still small, scarcely 300 men. Its influence for public welfare is not so much *their* contributions to science and industry, as *his* contribution, as a pioneer in industrial research, in demonstrating what was by no means obvious, that pure research can be successfully carried on in an industrial laboratory, with profit and untold benefit to mankind.

For this eminence in the application of science to public welfare I commend to you Dr. Willis Rodney Whitney, pioneer of industrial research.

Dr. Whitney, in gratefully accepting the medal, expressed sincere appreciation of the honor bestowed on him as "representing a living active group of research men."

In our particular research-group our duty is to help counteract the effects of obsolescence of electrical products and prevent interruption of employment of large groups by actively aiming at new electrical unknowns.

In such work we also found, somewhat as a by-product, that our research men could contribute to growing science by publishing their results. They have now published about one thousand scientific articles. These, I like to feel, are contributing thus to general knowledge and public welfare.

F. E. WRIGHT,
Home Secretary

NATIONAL EXHIBITION OF THE WORKS OF JOHN J. AUDUBON

ONE hundred and four original paintings and drawings by John James Audubon, the celebrated artist-naturalist of the nineteenth century, were displayed at the Academy of Natural Sciences of Philadelphia from April 26 until June 1.

The showing of this collection marked the one hundredth anniversary of the publication of "Birds of America," one of natural history's proudest monuments. These elephant folio volumes were completed in London, in 1838, seven years after Audubon had been elected a member of the academy in 1831.

The exhibition was arranged by divisions so that the visitor would be able to visualize the artistic progress Audubon made in his lifetime of portraying animals. The first section was devoted to his earliest French drawings. Though they are in many cases crude and awkward representations, all of them show evidence of his remarkable eye for color.

Following this section were those showing paintings made while a resident at "Mill Grove" near Philadelphia, in Kentucky and in Louisiana. In this later division Audubon begins to reach the full heights of his artistry. His birds have become tremendously alive and assume colorful lifelike poses.

This period is likewise important as it marks the artist's debut as a portrait painter and his first experiments in oil. An interesting portrait in chalk was that of General and Mrs. Lytle, done in 1821, at Cincinnati. By such sketches as these Audubon was able to gain a meager livelihood and continue his work on the "Birds of America."

Two other divisions devoted to paintings were exhibited—those done while in England and America between 1826 and 1838 and his Quadruped paintings done from 1838 until death in 1851. The Quadruped paintings have long been overlooked by many Audubon admirers. The artist is particularly facile in drawing small animals, and his talent was never better demonstrated than in the drawing of "Richardson's Squirrels."

In addition to the paintings, the academy's exhibition showed a comprehensive collection of Audubonian, such as letters, journals and editions of his works, as well as copper plates and engravers' proofs. To many, the original subscription list with the names of the subscribers to the parts of the elephant folios of the "Birds" is of outstanding interest. Here we see evidence that Audubon, though a business failure in his youth, was able in maturity to engineer one of the most gigantic jobs of publishing ever undertaken. Two hun-

AUDUBON IN THE FIELD
OIL PAINTING BY HIS SON, JOHN W. AUDUBON.

dred and seventy names appear on the list, which is headed by George IV and the Duchess of Clarence, and, in addition, contains the names of Baron Cuvier, Daniel Webster and Henry Clay, Jr.

The method Audubon followed in making his drawings for publication was shown in an exhibit of the four sketches and drawings of the "Soft-Haired Squirrel." Here he first made a rough pencil sketch, then individual finished

THE GREAT COCK OR WILD TURKEY

AN OIL PAINTING WHICH FORMERLY HUNG IN THE HOUSE OF AUDUBON AT MINNIE'S LAND AND WAS LENT THE EXHIBITION BY AUDUBON'S GREAT GRANDSON, VICTOR M. TYLER, NEW HAVEN, CONN.

sketches of the two animals and finally one of the background with the spaces the animals were to be placed in indicated for the engraver.

One of the simplest but most graphic exhibits in the show is a small map marking the courses of Audubon's travels throughout America, frequently by foot or flatboat. This is a chart of one man's intense fight for success. Twelve times during his life he crossed the Atlantic and many weary miles were traveled alone and unknown throughout Europe and America in the not pleasant rôle of salesman for a work difficult to sell to scientists, much less total strangers.

A comprehensive catalogue of the exhibition has been prepared, which aside from containing information on all the items in the show, has an introductory essay prepared under the direction of Dr. Witmer Stone which discusses Audu-

bon's association with the academy. The catalogue is illustrated with ten half-tone engravings and may be purchased, post-paid, by sending 25 cents to the academy, 19th Street and The Parkway, Philadelphia.

More than thirty different museums, libraries and collectors, including three descendants of Audubon and a descendant of Robert Havell, the English engraver of the "Birds of America," lent material to the exhibition. Particular care was taken to gather from all parts of America interesting Audubon items so that the exhibition would be truly national in scope.

In presenting its exhibition, the academy attempted to make an appreciative public fully aware of Audubon's talent.

John H. Fulwiler

THE HALL OF SCIENCE AT THE SAN FRANCISCO FAIR

An attempt will be made to interest a wide public in the advancement of science through exhibits in the Hall of Science of the 1939 Golden Gate International Exposition in San Francisco; institutions and individuals are cooperating on a large scale. Where it is possible, fully equipped research laboratories will be open for inspection. Elsewhere, special displays will reproduce the conditions of plant and animal life on simplified or enlarged scales. Biology, chemistry, psychology, physics and medicine will be represented by specialists in their fields.

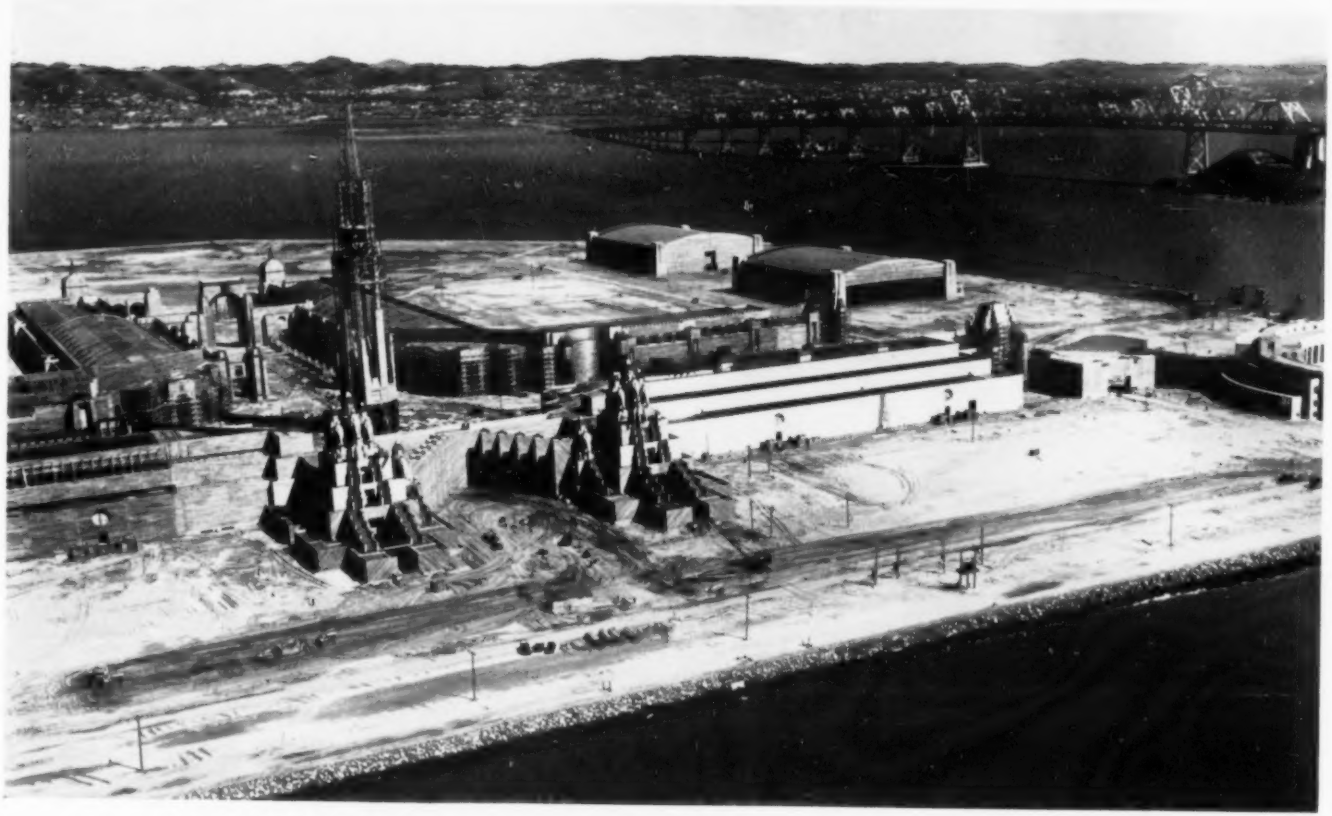
As a part of the exhibit of the University of California, on which $200,000 will be expended, a full-size model of the 220-ton atom-smashing cyclotron, now being erected at its radiation laboratories in Berkeley, will be seen in simulated operation. All the details of its construction are to be accurately reproduced. Instead of the invisible, dangerous neutrons that ordinarily whirl about in the vacuum chamber, however, steel balls will wind slowly outward in spiral paths to illustrate their motion. Actual samples of radioactive material produced by the cyclotron will be demonstrated behind ample shielding to protect observers.

Another demonstration from the University of California will be the story of life from the top of the highest mountain to the sea bottom. To present a simple, complete picture, representations of plants and animals will be placed at the proper heights at the side of a miniature mountain 35 feet high. Entering a shaft located inside the mountain, visitors will descend to a model bathosphere suspended among models of deep-sea life as they would appear to an observer beneath the ocean. Near-by will be shown miniature trawlers, oceanographic vessels and other craft with equipment for recording deep-water temperatures, depths and for collecting samples.

In the biological division of the Hall of Sciences the life cycles of the salmon and eel are to be realistically portrayed, as well as specimens of other fish in their natural habitats. Specially designed lighting effects will be employed for a closer resemblance to nature, and trained speakers will be on hand to lecture at scheduled hours.

At the plant exhibit the roots of growing plants will be seen extending into transparent bowls of water treated with soluble nutrients. By regulating the nutrient formulas in such a way as to withdraw different fertilizing elements from the food of specimens, the consequences of such defects on growth and health can be readily observed. Special devices will magnify the internal structure and life processes of plants.

The directors of the Hall of Science intend to demonstrate as large a number of subjects of scientific interest as possible and in such a way that they will be appreciated by visitors who have no special technical knowledge. Bacteria operating in different media will produce a variety of products—among them perfumes, flavorings, medicines and hormones. The public will be able to see the production in test-tubes of fats, proteins



AN AERIAL VIEW OF EXPOSITION BUILDINGS UNDER CONSTRUCTION

IN THE FOREGROUND THE ELEPHANT TOWERS, FLANKING THE MAIN ENTRANCE, ARE TAKING DEFINITE FORM. BEYOND, IN THE COURT OF HONOR, IS THE 400-FOOT TOWER OF THE SUN. AT THE EXTREME RIGHT CAN BE SEEN A PART OF THE $1,000,000 ADMINISTRATION BUILDING, TO BECOME THE TERMINAL BUILDING WHEN TREASURE ISLAND REVERTS TO AN AIRPORT AT THE CONCLUSION OF THE EXPOSITION. IN THE BACKGROUND ARE THE CITIES OF BERKELEY AND OAKLAND.

A MODEL OF THE GOLDEN GATE INTERNATIONAL EXPOSITION

TO BE HELD ON TREASURE ISLAND IN SAN FRANCISCO BAY IN 1939. THE MODEL IS 16 FEET LONG, 7 FEET WIDE AND IS BUILT ON A SCALE OF 150 FEET TO THE INCH. IT WEIGHS MORE THAN A TON. THE HALL OF SCIENCE IS IN THE CENTER OF THE PICTURE EXTENDING TO THE LEFT FROM THE TOWER. THE BERKELEY HILLS AND THE BUILDINGS OF THE UNIVERSITY OF CALIFORNIA CAN BE SEEN IN THE BACKGROUND.

and sugars from non-organic materials. Sugar will be synthesized from carbon dioxide and water and, in turn, treated with nitrogen to form a protein.

Thirty outstanding research laboratories have volunteered to illustrate the story of progress in the treatment and prevention of disease. Led by the American Medical Society, the Mayo Clinic and the American Society for the Control of Cancer, they will present a picture of contemporary advances in medicine and related fields. A complete health exhibit will demonstrate the importance of proper nutrition, vitamins, sanitation and other methods of public health.

Mechanical models and a transparent man will demonstrate human physiology and the functioning of the bodily organs in conjunction with the effects of drugs and the digestion of food. Close by will be shown the latest practices in cancer treatment, plastic bone surgery, the uses of radium, the x-ray and insulin and an outstanding embryological display, "How Life Begins."

Among others, the American Dental Association exhibit will be one of the most complete of its kind, combining a history of past and recent progress with an illustration, by means of model heads and jaws, of the effects of evolution, racial differentiation and diet on dental structure.

THE TOWERS OF TREASURE ISLAND

AT THE LEFT ARE THE MASSIVE TWIN ELEPHANT TOWERS FLANKING THE MAIN ENTRANCE TO THE FAIR; AT THE RIGHT IS THE 400-FOOT TOWER OF THE SUN SURMOUNTED BY A GOLDEN PHOENIX. IN THIS TOWER WILL BE A CARILLON OF FORTY-FOUR BELLS.

It is the intention of the directors of the Hall of Science to give visitors with no special training a clearer understanding of the physical and biological sciences. To this end leading universities throughout the country are cooperating notably—the University of California, Stanford University, the California Institute of Technology, the University of Southern California, Harvard University, the University of Oregon and the University of Washington.

MORT FRIEDLANDER